OPTIMIZING LAND FOR SUSTAINABLE URBAN DEVELOPMENT IN THE CITY

Project Phase-II Report submitted to

Visvesvaraya National Institute of Technology, Nagpur

In partial fulfilment of the requirements for the award of the degree

Master of Technology

In

Urban Planning

By

Yashika Pradhan (MT23UPL001)

Under the guidance of

Dr. Sarika Bahadure

Department of Architecture & Planning

Visvesvaraya National Institute of Technology, Nagpur 440010

(India)

2024-25

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Department of Architecture and Planning

Visvesvaraya National Institute of Technology, Nagpur

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Dr. Sarika Bahadure

Assistant Professor,

Dept. of Architecture and Planning,

VNIT, Nagpur

Head, Department of Architecture and Planning

VNIT, Nagpur

Date:

Visvesvaraya National Institute of Technology, Nagpur

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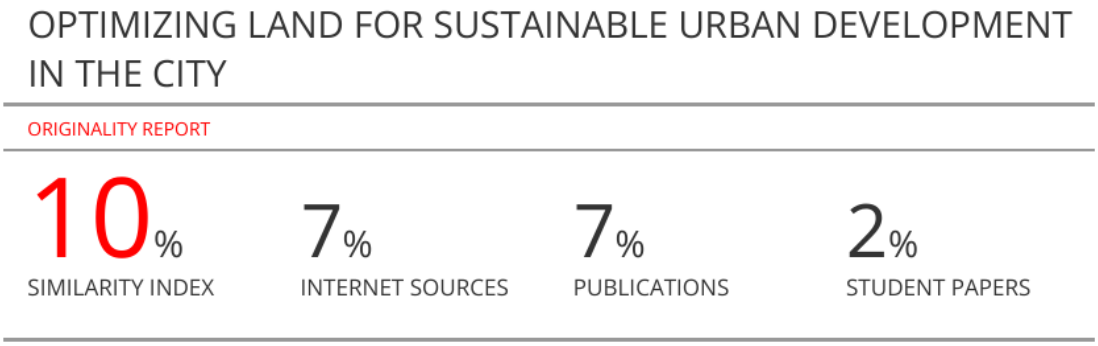

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Dr. Sarika Bahadure

Assistant Professor,

Dept. of Architecture and Planning, VNIT, Nagpur

Department of Architecture and Planning
Visvesvaraya National Institute of Technology, Nagpur

Acknowledgement

I would like to take this opportunity to express my profound gratitude to my project guide, **Dr. Sarika Bahadure**, Assistant professor at the Department of Architecture and Planning, for her invaluable guidance, insightful suggestions, and unwavering support throughout this research journey. Her expertise and encouragement have been pivotal in shaping my work and enhancing the quality of this dissertation.

I also extend my sincere thanks to **Dr. Sameer Deshkar**, the Head of the Department, and **Dr. Prem Lal Patel**, the Director of VNIT Nagpur, for fostering a supportive academic environment. I would also like to extend my thanks to the PG Coordinator, **Dr. Pankaj Verma**, for their assistance and coordination in the completion of this project. Additionally, I am grateful to faculty members **Dr. Rajashree Kotharkar** and **Dr. Meenal M. Surawar** for their contributions and encouragement, which have greatly enriched my academic experience.

I would also like to thank my friends and seniors for their guidance and support. Lastly, I would like to express my heartfelt appreciation to my family for their unwavering support and encouragement throughout this journey. Their love and belief in me have been a constant source of strength, motivating me to overcome challenges and pursue my goals with determination.

Their collective support has been instrumental in my pursuit of academic excellence, and I am deeply appreciative of everyone's commitment to my success.

Yashika Pradhan
(MT23UPL001)

ABSTRACT

Urban planners face the critical challenge of rapid urbanization, which demands harmonizing economic growth, social equity, and environmental sustainability. With land being a limited natural asset, its use should be optimized through responsible management, reduced ecological impact, and the preservation of essential agricultural zones. Unregulated urban expansion often causes harmful sprawl in peri-urban areas. Therefore, planned development is necessary to ensure sustainable growth, efficient land use, and thorough land suitability assessments. Integrating Land Suitability Analysis into urban planning is an effective method for achieving land optimization.

The study examines how land suitability assessment, when integrated into urban planning, can contribute to sustainable development and influence city growth. Bhubaneswar, identified for assessment as a rapidly growing Tier II city, requires strategic planning to ensure sustainable growth and effective population management. The assessment is conducted using eighteen indicators within five thematic groups, analysing the city's demographics, population density, social infrastructure, growth patterns, and land-use transformation. After analysing the data and developing a suitability map, the study proceeds to assess the city's carrying capacity to understand its potential. Based on the classification of land as suitable or unsuitable, vacant plots within the city can be designated for the most appropriate uses. Emphasizing efficient use of land within existing boundaries is recommended prior to any outward expansion. This strategy is intended to increase the city's carrying capacity and support sustainable urban development.

By using the suitability map, vacant land parcels have been identified as suitable or not suitable for development. The analysis, along with the city's existing conditions, guided the allocation of land uses that are currently lacking, based on accepted norms. In addition, a range of land management strategies and policy recommendations have been put forward to optimize land use. These findings highlight the significant role of land suitability assessments in improving land use planning and efficiency, which in turn supports sustainable urban development. In the future, as urban analysis becomes more complex with additional indicators, integrating AI and machine learning will enhance the accuracy and efficiency of land suitability evaluations, supporting smarter urban planning decisions.

Keywords: Land, Land Suitability, Land Optimization, Sustainable Development, Indicators, Tools;

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Abbreviations

LSA	Land Suitability Analysis
GIS	Geographic Information Systems
MCDA	Multi-Criteria Decision Analysis
AHP	Analytic Hierarchy Process
LULC	Land use Land cover
CC	Carrying Capacity
SDGs	Sustainable Development Goals
TOD	Transit-Oriented Development
BMC	Bhubaneswar Municipal Corporation
BDA	Bhubaneswar Development Authority
NDVI	Normalized Difference Vegetation Index
AQI	Air Quality Index
LST	Land Surface Temperature
FAR	Floor Area Ratio
P SP	Public Semi-Public

CHAPTER-1 INTRODUCTION

1.1 Background

Urban development and population growth create a demand for land designated for residential, commercial, recreational, public, semi-public, and industrial uses, as well as for transportation and other infrastructure. Land is a limited natural resource, it is crucial to utilize it efficiently [1]. To address rising demand, it is important to maximize land utilization to its fullest potential, rather than misusing it. A key factor for planned urban growth is evaluating land suitability criteria, which provides guidance for development and helps reduce ecological footprints while increasing ecological capacity. Efficient land use is essential to meet these suitability criteria [2].

Urban development and population growth create a demand for land designated for residential, commercial, recreational, public, semi-public, and industrial uses, as well as for transportation and other infrastructure. Land is a limited natural resource, it is crucial to utilize it efficiently [1]. To address rising demand, it is important to maximize land utilization to its fullest potential, rather than misusing it. A key factor for planned urban growth is evaluating land suitability criteria, which provides guidance for development and helps reduce ecological footprints while increasing ecological capacity. Efficient land use is essential to meet these suitability criteria.

When developing various facilities, such as residential and industrial areas, assessing land suitability is vital to determine the appropriateness of a location. This evaluation ensures that development occurs in the most suitable areas, thereby protecting valuable agricultural and green spaces from unnecessary conversion.

Thus, it is important to evaluate the situation and conduct land suitability assessments and optimization processes to mitigate urban sprawl and its adverse environmental impacts. This aligns with one of the major objectives of the Sustainable Development Goals (SDG 11-11.3) [1]. Conducting such assessments will determine areas most suitable for various land uses and thus allow for proper allocations of lands according to the necessities of amenities needed. This further can contribute to reducing the rate of land consumption per person [1]. Furthermore, policymakers can make informed decisions to balance economic growth, social equity, and ecological preservation based on the results of land suitability analyses.

1.2 Need of the study

For efficiently accommodating the rising needs for infrastructure and urbanization, efficient land use needs to be optimized. Optimization is done by choosing land suitability criteria that are suited to the particular growth trends, population dynamics, and topographical conditions of the city. By making land use conform to such criteria, urban sprawl and environmental degradation can be minimized. In addition, land management, environmental conservation, and sustainable development policy integration ensures land use efficiency for long-term ecological stability and robust urban development. This optimization stimulates compact development, optimizes utilization of underdeveloped areas, and employs smart technologies such as Geographic Information Systems (GIS) for real-time monitoring and decision-making. Ultimately, this strategy ensures sustainable and economically active urban space.

1.3 Aim

To optimize land for sustainable urban development in the city using land suitability assessment and carrying capacity.

1.4 Objectives

- To study best practices, indicators and tools for land suitability assessment.
- To select study area and study the existing policies, strategies and measures of land optimization.
- To collect data at city level for the identified indicators to access the existing urban condition.
- To perform analysis with indicators, carrying capacity, and developing suitability map.
- To suggest recommendation on the basis of analysis done with the help of suitability map.

1.5 Scope and Limitation

The land suitability assessments can be conducted at different administrative levels, this study is focused on the city level, examining the Bhubaneswar Municipal Corporation area. The study employs a range of land suitability indicators, grouped under five thematic categories.

Although a comprehensive land suitability assessment could incorporate a wide range of indicators, only a limited set was used in this study. The economic analysis focused exclusively on land prices, while the ownership review was restricted to vacant land parcels.

1.6 Research Query

The study investigates if Land Suitability Analysis (LSA) can serve as a strategic urban planning tool for harmonizing the development process with environmental conservation. The focus is on how LSA can systematically appraise and categorize land using different indicators and advise planners on how to deploy space for green spaces—such as parks, forests, wetlands, and agriculture—and identify areas where urban development is most appropriate.

The primary purpose is to investigate if the application of LSA in planning leads to more informed, data-driven decisions that help conserve essential natural resources, maintain ecological balance, and promote the efficient use of land for housing, infrastructure, and economic purposes. Ultimately, the inquiry is whether this approach can advance sustainable urban growth by preventing urban sprawl, reducing environmental impacts, and enhancing overall urban liveability.

1.7 Methodology

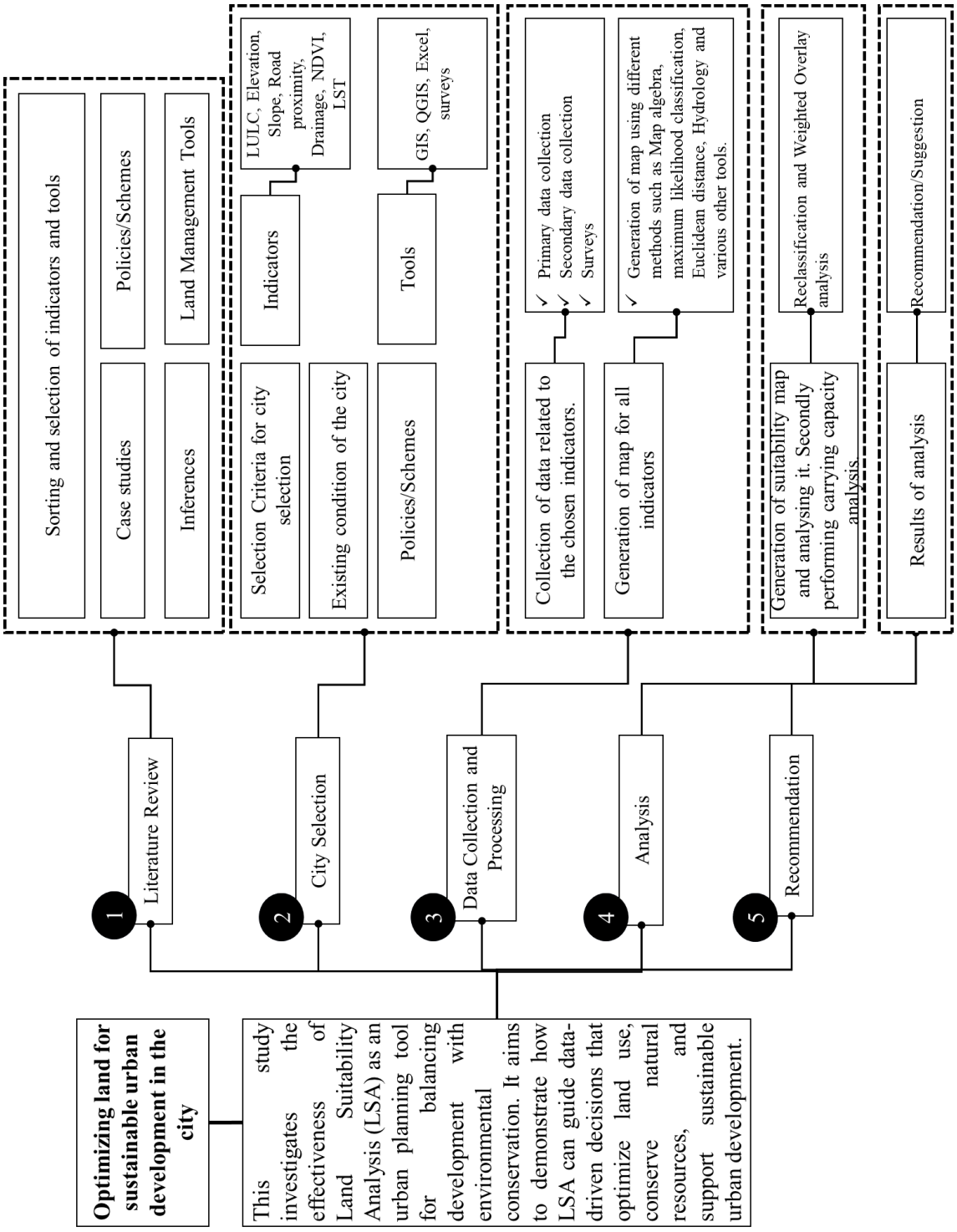

Optimizing land for sustainable urban development in the city
This study investigates the effectiveness of Land Suitability Analysis (LSA) as an urban planning tool for balancing development with environmental conservation. It aims to demonstrate how LSA can guide data-driven decisions that optimize land use, conserve natural resources, and support sustainable urban development.
1
Literature Review
Sorting and selection of indicators and tools
Case studies
Inferences
2
City Selection
Selection Criteria for city selection
Existing condition of the city
Indicators
LULC, Elevation, Slope, Road proximity, Drainage, NDVI, LST
Tools
GIS, QGIS, Excel, surveys
Policies/Schemes
Policies/Schemes
Land Management Tools
3
Data Collection and Processing
Collection of data related to the chosen indicators.
✓ Primary data collection
✓ Secondary data collection
✓ Surveys
4
Analysis
Generation of map for all indicators
✓ Generation of map using different methods such as Map algebra, maximum likelihood classification, Euclidean distance, Hydrology and various other tools.
5
Recommendation
Generation of suitability map and analysing it. Secondly performing carrying capacity analysis.
Reclassification and Weighted Overlay analysis
Results of analysis
Recommendation/Suggestion

Figure 1 Methodology

1.8 Chapterisation

Chapter -2: Literature Study

This chapter presents some of the salient terms associated with land, urban space, urban expansion, and green development and continues to examine the planning practices influenced by strategies, methodologies, policies, and legislation. It emphasizes on two main aspects of land suitability analysis: the selection and evaluation of relevant indicators using specific tools and methods. By using a series of regional and urban-level case studies, the chapter shows how these indicators and approaches are selected and applied in practice to meet actual planning issues. By drawing together insight from both case studies and literature, it offers useful conclusions to facilitate more efficient land suitability analysis and to advance sustainable, informed regional and urban planning.

Chapter 3: City selection

In this chapter, the city has been identified for the study, on the basis of different factors. After the city selection, an introduction to the city has been provided, with the policies and schemes related to city or state, as well as its basic information has been discussed.

Chapter 4: Data collection and Analysis

In this chapter, data is gathered for specific indicators to construct maps that illustrate the existing conditions of the city. After creating these maps, a suitability map is developed to separate land into suitable and unsuitable categories for development, helping in the identification of potential growth areas. Similarly, using other relevant data, the carrying capacity is calculated and a prediction map is created. Further, the chapter also examines the potentials and issues/challenges identified through the analysis, and outlines possible directions for recommendations, proposals, and suggestions aimed at optimizing land use for sustainable urban development in the city.

Chapter 5: Recommendations

The chapter presents recommendations and proposals based on the analysis and the identified issues and challenges, aimed at addressing and resolving them.

Chapter 6: Conclusion

CHAPTER-2 LITERATURE STUDY

This chapter covers key terminologies, strategies, policies, and legislation related to the topic. It also explains the process of selecting and categorizing various indicators and tools. Finally, it presents several case studies at both regional and city levels to demonstrate how land suitability analysis supports urban planning decisions and helps address urbanization challenges.

2.1 Glossary

This glossary explains terminology associated with land, urban, and green development.

2.1.1 Land Terminologies

Land plays a crucial role in planning, particularly in land use planning, which involves the systematic assessment and organization of land resources to meet various human needs while ensuring environmental sustainability (ref. table 1).

Table 1 Land related terminologies

Terms (Sources)	Definition/Description	Emphasis	Units/measurement scale
Land Use (a) [3]	"Land-use" is associated to human activities on land, such as agriculture, buildings, roads, etc. It related to how human activities and their habitats have used the land, keeping in mind the functionality and importance of land in economic activity and overall development as focus	• Compatible land uses: • Residential, commercial, Public-semi-public, Industrial, agricultural, forest, Transportation, etc.	• Scoring Systems • Suitability Classes • Weighted Overlay Method • Qualitative and Quantitative Assessments • Sq.km. /Ha. /Acre
Land Cover (b) [4]	Land cover describes the physical aspects of the earth's surface, both the natural and the artificial features, as represented by the distribution of flora, water, soil, and other land features, including those caused exclusively by human activity.	• Physical aspects such as: • Green cover (this includes all green areas, forest, agricultural, open areas, etc), • Built-up (this covers residential,	• Sq.km. /Ha. /Acre. • Percentage (%)

		commercial, industrial, etc.) • Water (includes: water bodies, canals, ponds, etc.)	
LULC (c) [4]	LULC: Land use and land cover change (LULC change) is a significant term that highlights human activities that alter the Earth's terrestrial surface. In simpler terms, land use change refers to either (a) conversion from one type of land use to another; i.e., a transformation in the pattern of land uses in an area, or (b) land use modification.	• Combination of (a) land use and (b) land cover.	• Sq.km. /Ha. /Acre. • Percentage (%). • Suitability Classes
Land use planning (d) [5].	Land use planning is a discipline that focuses on the efficient use of land based on ecological and socioeconomic factors. It involves selecting and managing land use, such as development, without considering land capability, which can lead to disinvestment and reduced environmental capacity	• (c) LULC and (e) Land use density plays an integral part while planning a city.	• Sq.km. /Ha. /Acre. • Percentage (%).
Land use density (e)	Land use density is the measure of the intensity of development within a certain area of land. It indicates the number of developed units, such as housing, jobs, or population, per unit of land area. Density plays a critical role in urban planning and development, as it impacts several aspects of the built environment.	• Required for planning areas. • It will help in understanding the pressure in the patch of land, accordingly the amenities, infrastructure, can be provided, to cater the requirements of present as well as future.	• Units per Area • Gross vs. Net Density • Population Density • Floor area ratio (FAR)
Land Capacity [6]	Land capacity is the land's natural ability to support different uses without causing harm. Land capability assessments evaluate land's physical characteristics to determine its suitability for various uses like agriculture, forestry, or	• Suitability assessment • Land management • Policy planning • Land-use planning • Potential land	• Sq.km. /Ha. /Acre. • Percentage (%).

	urban development. These assessments help us understand the land's potential and how to use it sustainably.		

2.1.2 Urban Terminologies

Table 2 Urban related terminologies

Terms	Definition/Description	Emphasis
Urban	"**Urban**" in India is defined as a human settlement with a minimum population Urban of 5000 persons, with 75% of the male working population engaged in non-agricultural activities and a population density of at least 400 persons per sq. km. [7].	Define urban area in reference to how city area is different from village/rural area.
Urbanisation	Urbanization is the process of people moving from rural areas to cities, causing cities to grow and the rural population to shrink. This shift leads to an increasing concentration of people in urban areas, resulting in the development and expansion of cities.	Defines migration of people and rising issues with it.
Peri-Urban Areas	Peri-urban areas are transitional zones between rural and urban areas, often characterized as a mix of rural and urban features. These areas represent the interface where rural and urban land uses overlap [8].	Emphasising of transitional areas, which are most important to be taken care of for future development
Urban Land	Urban land refers to areas within cities or towns that are designated for various purposes, including residential, commercial, industrial, and institutional uses. These areas are typically characterized by high population density and developed infrastructure, including buildings, roads, and utilities, which support urban living and economic activities.	Areas within cities or towns.
Urban Growth	Urban growth is the expansion and development of urban areas, driven primarily by the movement of people from rural to urban regions. This process, known as urbanization, results in a significant increase in the population of cities. As cities grow, they often expand into surrounding areas, such as suburbs and rural regions, further contributing to urban growth. This expansion can have both positive and negative impacts on the environment, economy, and social fabric of a region.	Expansion of the boundary of cities for future urban development.
Urban Expansion	Urban expansion is the process of cities spreading into surrounding rural areas due to population growth and economic development. This involves	To mitigate these issues, effective urban planning is crucial. This includes

	converting rural land into urban areas, leading to larger cities and the incorporation of nearby towns and villages.	creating a sustainable development framework that addresses infrastructure, environmental protection, and the needs of both urban and rural communities [9].
Urban Sprawl	Urban sprawl, also known as suburban sprawl, refers to the uncontrolled and often unplanned expansion of urban areas into surrounding rural land. It involves the encroachment of urban development into areas designated for vegetation, agriculture, water bodies, and open spaces [10].	• Identification of areas which are unplanned • Identification of encroached areas
Urban sprawl and land-use change	Urban sprawl and land use change result from the complex interaction between inhabitants' behaviour and macro and micro factors associated with urban land demand [11].	Interrelation of Urban sprawl and land use change, how it affects urban planning.

2.1.3 Green development Terminologies

Table 3 Green development related terminologies

Terms	**Definition/Description**	**Emphasis**	**Units/measurement scale**
Environment	"Environment" includes water, air and land and the inter- relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property [12].	Emphasis on environment related issues and how development is affecting it.	**Temperature**: degrees Celsius (°C) or Kelvin (K). **Humidity**: percentage (%) **Air Quality**: Air Quality Index (AQI); PM2.5 and PM10;
Ecological Balance	Ecological balance is a state where an ecosystem's diversity remains relatively stable, with balanced populations of various species. This balance can be disrupted by natural or human-caused disturbances, leading to ecological imbalance. When an ecosystem is out of		

	balance, it can face resource depletion, habitat destruction, and species loss [13].		
Environmental Degradation	Environmental degradation is the damage to the natural environment caused by the depletion of resources like air, water, and soil, as well as the destruction of ecosystems and loss of biodiversity.	It defines the degradation of environment caused by development	
Carrying Capacity	Carrying capacity refers to the maximum number of individuals that an environment can support over time. It is determined or calculated by the resources available such as food, water, and habitat. This is an important concept in ecology and population dynamics because it helps in understanding the limits of population growth about environmental constraints.		

2.2 Land Suitability

Land resources are essential for human survival and development, providing the foundation for growth. However, over 75% of the Earth's land has been degraded by urban growth and human activities, putting immense pressure on natural resources. This leads to challenges such as land degradation, biodiversity loss, and climate change. To address these issues, a rational approach to resource use that promotes ecosystem resilience is needed. Land resource planning aims to facilitate sustainable land use that meets human needs while protecting natural resources for future generations [14]. Rapid urbanization further complicates this, as it necessitates land for various purposes, highlighting the importance of wise land resource management.

2.2.1 Importance of Land optimization

Land optimization is a crucial strategy for achieving sustainable urban land use planning. This approach aims for long-term balanced urban development by promoting economic prosperity, efficient resource utilization, environmental protection, and social equity. It involves the allocation of various land uses—such as residential, industrial, commercial, recreational facilities, open spaces, parks, and green areas—in a manner that maximizes overall benefits.

2.2.2 Land suitability Assessment

Land suitability assesses how well a specific area is suited for various uses like agriculture, forestry, or urban development by evaluating its characteristics. This analysis is crucial for determining appropriate locations for residential and industrial facilities, which helps protect agricultural land and promote sustainable development.

Effective land suitability analysis allows planners to create sustainable development plans, allocate resources wisely, and curb unplanned urban sprawl, while also addressing challenges such as urban blight. It plays a key role in meeting Sustainable Development Goals (SDGs) [15], particularly SDG 11.

By optimizing land use and identifying areas best suited for development, policymakers can balance economic growth, social equity, and ecological preservation. Land suitability studies aid urban planners in zoning regulations and holistic urban planning, supporting sustainable development efforts aligned with the SDGs. Land Suitability helps in:

Land Utilization: Proper land utilization is crucial to prevent the degradation of land resources and reduce the risk of desertification, which is closely linked to climate change. By using land based on its capabilities, it can help to sustain resources over time without harming the environment. Effective land management is essential for achieving sustainable development and protecting the environment. With climate change, population growth, and urban sprawl putting pressure on agricultural land, it's imperative to use suitable techniques to select land for urban development for this it is important to do land suitability analysis so that land can be used efficiently to its full capacity [16]; (DELIRY & UYGUÇGİL, 2020); (Kerebeh, 2020); [17];

2.3 Strategies/approaches to optimize land utilization

Optimizing land use for urban development is crucial, as it allows us to balance economic growth, environmental preservation, and social well-being. We have a range of approaches available, from reducing environmental impact to preserving biodiversity and managing urban growth. These approaches are interconnected and work together to create effective urban plans. In the same way that transportation, land use, and infrastructure depend on each other, our approaches to urban development also rely on a cohesive and interconnected strategy. This interdependence is key to optimizing our utilities.

- ✓ Strategic Planning

- ✓ Smart growth
- ✓ TOD

2.3.1 Strategic Planning

Strategic Planning is one of the important aspects to be considered while planning as it helps in anticipating the future challenges and opportunities and also allows in providing direction for further growth and development. It helps in adapting to changes such as population growth, economic shifts, and environmental impacts. In strategic planning, there is the involvement of various stakeholders in decision-making, this collaborative approach fosters inclusivity and ensures that diverse perspectives are considered in the planning process [18] [19] [20]. (ref. fig. 2)

Some key aspects and approaches to strategic planning in urban contexts:

- Compact development
- Regularised development in peri-urban areas
- Integration of Urban and rural land development
- Community involvement
- New Urbanism (ref. fig. 2)
- The 15-Minute City Concept
- Comprehensive Land Use Planning
- Urban Growth Boundaries (UGBs)

2.3.2 Smart Growth

Smart growth focuses on providing guidance and direction for development in a sustainable manner, it also considers economically vibrant, socially equitable, and environmentally sustainable (ref. fig. 3). Some of the key principles also help in developing urban areas with its full capacity as there is only limited resource (land) on which development can be done. So, many strategies and approaches were made for better utilization of land and also to provide or increase quality of life for people living and it also directly or indirectly helps in reducing negative environmental impact [21].

Key aspects and principles of smart growth:

- Infill Development and Adaptive Reuse
- Walkable Neighbourhoods (ref. fig. 3)
- Mixed Land-Use
- Public transportation
- Integrated land use planning

A. Mixed-Use Development

A mixed-use development integrates various functions such as retail, office, residential, hotel, and recreational spaces. It prioritizes pedestrian accessibility, creates a dynamic "live-work-play" environment, and effectively combats traffic congestion and urban sprawl (ref. fig. 4). Additionally, the diverse range of activities within these developments undeniably benefits service providers, as they can complement each other's offerings in the exchange of goods and services [22].

2.3.3 Transit oriented development (TOD)

Transit-Oriented Development (TOD) is an urban planning strategy that prioritizes the well-being of residents, the environment, and transportation systems (ref. fig. 5).

TOD ensures the efficient utilization of public transportation infrastructure, maximizing the accessibility and efficiency of transit services, and making them more appealing and accessible to a wider range of users [23].

Key aspects and principles of TOD:

- Mixed Use Development
- High Density Development
- Promote Public transport
- Influence Zone 500-800m
- Promote NMT
- To prevent urban sprawl
- Reduce carbon footprints

a

Walkability
Pedestrian friendly design
Front porches
Tree lined streets
10 minute walk radius
Connectivity
Interconnected street grid network
Narrow streets, boulevards, and alleys
Mixed-Use & Diversity
Live, work, shop within within blocks, and within buildings
Diversity of people - of ages, income levels, cultures, and races
Mixed Housing
A range of types, sizes and prices in closer proximity
Quality Architecture & Urban Design
Creating a sense of place;
Placement of civic uses and sites within community.
Human scale architecture
PRINCIPLES OF URBANISM
Traditional Neighborhood Structure
Public space at center
A range of uses & densities within 10-minute walk
Transect planning: Highest densities at town center
Create mix of natural habitats & urban settings.
Increased Density
More buildings, residences, shops, and services closer together
A more efficient use of services and resources,
To create a more convenient, enjoyable place to live.
Green Transportation
A network of high-quality mass transit connecting cities, towns, and neighborhoods
Pedestrian-friendly design that encourages a greater use of bicycles, rollerblades, scooters, and walking as daily transportation
Sustainability
Minimal environmental impact of development and its operations
Eco-friendly technologies & value of natural systems
Energy efficiency
Less use of finite fuels
More local production
Quality of Life
Pride in sense of place
Healthier spaces that contribute to wellbeing.

b

Figure 2 The 15-minute city framework (a); Principles of New Urbanism [24] (b);

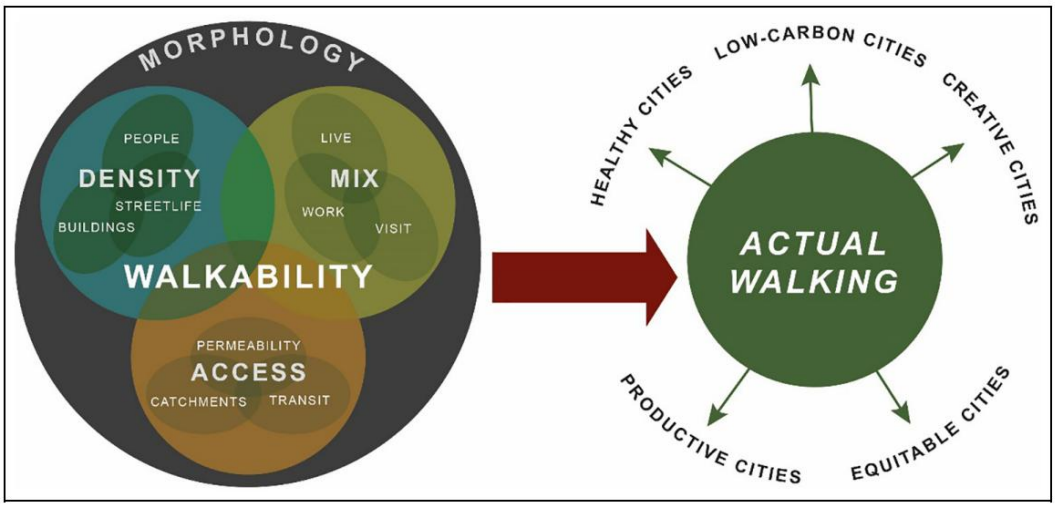


Figure 3 The Urban DMA (Density, Mix, Access) – Walkability and actual walking [25].

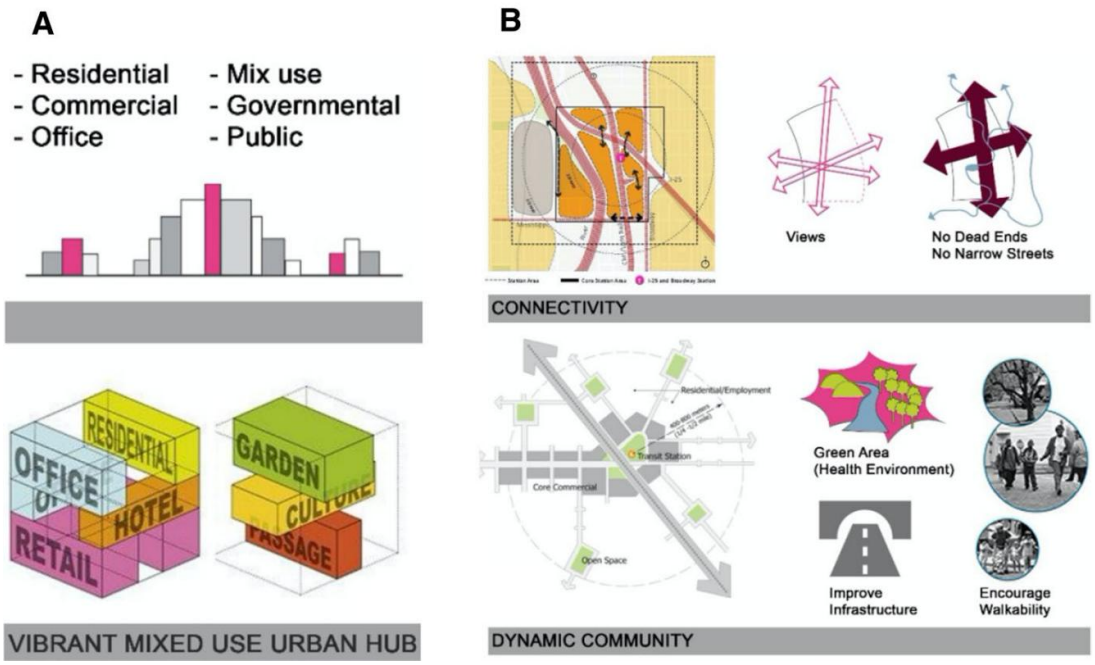
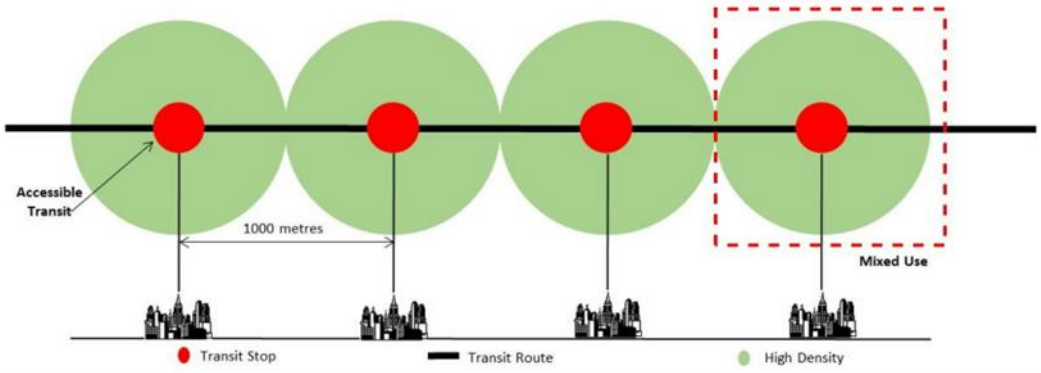
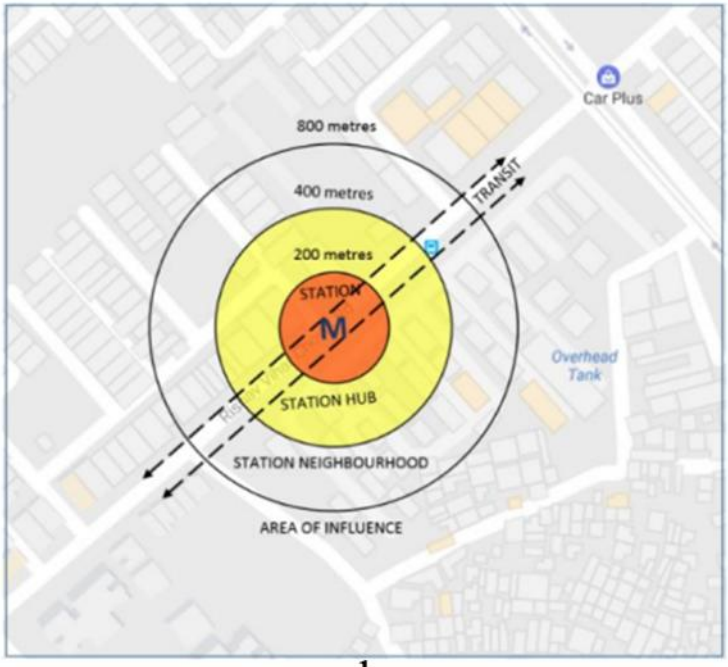


Figure 4 (a) Planning recommendation based on mixed-use hub; (b) planning recommendations based on the concept of connectivity and diversity [26].



a



b

Figure 5 TOD along transit station (a); TOD influence zone (b);

2.4 Policies and Acts

2.4.1 National Land Utilization Policy

A. Guiding Principles

- **Placing Human Beings at the Forefront:** Prioritizing the well-being of people is essential for sustainable development, ensuring they live healthy and productive lives in harmony with nature.

- **Inclusive Growth, Poverty Eradication, and Gender Equality:** These elements are vital for India's sustainable development and should be integrated into all policies and programs to promote equal opportunities [27].
- **Balanced Development and Intergenerational Justice:** Planning must meet the needs of both present and future generations while minimizing large-scale population displacement [27].
- **Efficient Resource Utilization and Impact Mitigation:** Long-term land use planning should prioritize recycled, degraded, or un-irrigated lands, while preserving biodiversity and water resources [27].
- **Integrated Development Planning:** Planning should be comprehensive, sustainable, and incorporate the interests of all sectors and stakeholders [27].
- **Role of State Governments:** States must eliminate unsustainable land use practices and support transparent land use planning [27].
- **Harmonization with Existing Frameworks:** Current constitutional provisions and laws concerning land use will guide decisions and any policy changes [28].

2.4.2 73rd and 74th Amendment Act,1993

The 73rd and 74th Constitutional Amendments, which were passed in 1992 and which came into force from 1993, are significant milestones in India's decentralization journey. The 73rd Amendment [29] made Panchayati Raj in rural India constitutional by including Part IX in the Constitution and providing the Eleventh Schedule containing a list of 29 local government subjects. It created a three-tier system—Gram Panchayat, Panchayat Samiti, and Zila Parishad [30]; provided for direct elections, five-year fixed terms, and required the establishment of State Election and Finance Commissions. It also reserved seats for women and weaker sections.

The 74th Amendment [29] served a parallel role for urban India by giving constitutional status to Urban Local Bodies: Nagar Panchayats, Municipal Councils, and Municipal Corporations [30] by way of Part IXA and the Twelfth Schedule that allocates 18 functions to municipalities.

Both the amendments aimed at giving strength to local bodies, decentralizing powers and responsibilities, and promoting participatory governance. Despite these reforms, local bodies still face obstacles such as limited financial autonomy and administrative

challenges, requiring ongoing reforms to realize the full potential of decentralized governance.

2.5 Research papers

For conducting land suitability analysis, it is important to select certain criteria, on the basis of which the study or analysis can be conducted. To select criteria/factors more than fifty papers were reviewed. The search was done on the basis of keywords such as: Land suitability, Land management, management strategies, land-use, sustainable development, sustainable management, Land optimization, Land-use analysis, green development, urban growth, urban development, urban expansion, etc. All the papers are selected from the source- Google scholar, Scopus, and web of science.

From these fifty papers, thirty-seven (37) papers (ref. table 4) were selected for choosing criteria for land suitability. From these thirty-seven (37) papers, six papers were review papers and other thirty-one (31) papers were research papers.

The papers which were reviewed are mostly of developing nations (30 papers, rest 7 papers were of developed nations), as it will help in understanding the indicators which are selected for analysing a developing nation, as India is also a developing nation (see fig. 6). This whole study helped in analysing various indicators for land suitability analysis and also it helped in understanding various tools and methods used in conducting analysis for different indicators.

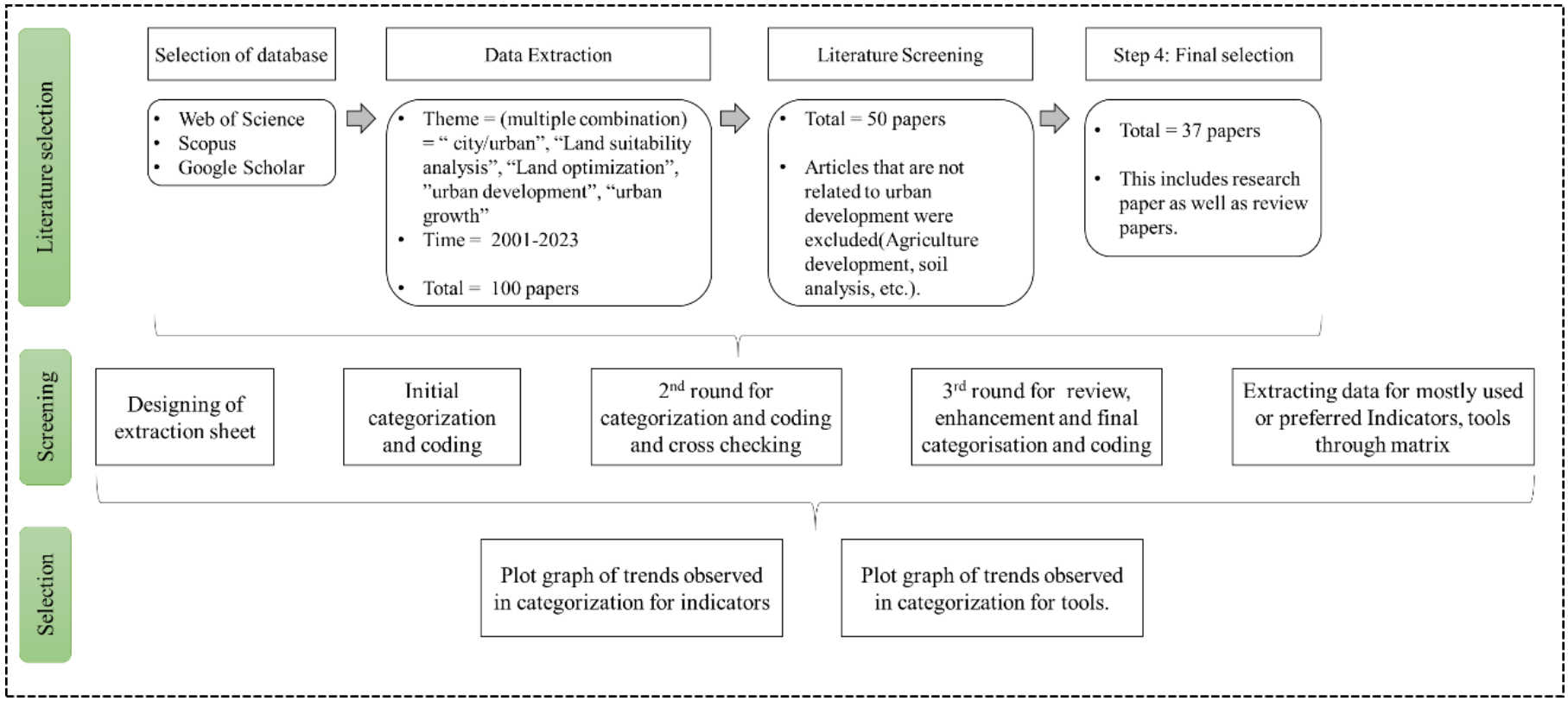

Literature selection
Selection of database
Web of Science
Scopus
Google Scholar
Data Extraction
Theme = (multiple combination) = " city/urban", "Land suitability analysis", "Land optimization", "urban development", "urban growth"
Time = 2001-2023
Total = 100 papers
Literature Screening
Total = 50 papers
Articles that are not related to urban development were excluded(Agriculture development, soil analysis, etc.).
Step 4: Final selection
Total = 37 papers
This includes research paper as well as review papers.
Screening
Designing of extraction sheet
Initial categorization and coding
2nd round for categorization and coding and cross checking
3rd round for review, enhancement and final categorisation and coding
Extracting data for mostly used or preferred Indicators, tools through matrix
Selection
Plot graph of trends observed in categorization for indicators
Plot graph of trends observed in categorization for tools.

Figure 6 Methodology for selecting, sorting, and screening of papers, indicators, tools and methods.

2.5.1 Themes for categorisation of indicators

From various studies it can be noticed that every study has their own criteria and indicators according to the type of development city requires, accordingly the evaluation criteria are set. To analyse the suitability of land and to provide with the better options for development/urban expansion while able to maintain the ecological balance, preserving biodiversity and maintaining environment, five themes have been selected under which indicators and sub-indicators have been divided for analysis.

Themes are:

1. Natural asset
2. Strategic planning
3. Ecological and environmental factors
4. Prohibitive factors
5. Social Attributes

A. Indicators

The term "indicator," or "indicans," refers to measures that allow conclusions about a phenomenon called the indicandum. Indicators can be categorized into economic, physical, social, and environmental types, each offering insights into different areas. Their effectiveness in reflecting changes in the indicandum depends on their sensitivity and specificity, helping stakeholders make informed decisions based on observable data. Understanding these classifications improves our ability to interpret and use indicators effectively [31].

Indicators are crucial for a comprehensive analysis and should be carefully chosen based on the specific context. This study on optimizing land use reviewed 119 indicators from various sources, eliminating duplicates and categorizing the remaining indicators by theme to enhance analysis. For instance, accessibility indicators provide information about proximity to roads and major hubs, while socio-economic indicators offer insights into distances from amenities and residential developments. These were combined under the accessibility category. Similarly, other indicators with related functions were grouped and further evaluated. Following this screening process, a final list of indicators was created (see Table 4).

Table 4 List of indicators from various studies

Natural asset	**I1**	**Strategic planning**	**I2**	**Ecological and environmental factors**	**I3**	**Prohibitive factors**	**I4**	**Social Attributes**	**I5**
Terrain elevation	**I1A**	**Accessibility**	**I2A**	**Hydrology**	**I3A**	**Exposure to geological hazard**	**I4A**	**Distance to vulnerable sites**	**I5A**
Slope	**I1B**	Distance to Roads of public transportation lanes	I2A1	Distance from groundwater	I3A1	Earthquake fault zone	I4A1	**Population density**	**I5B**
Land cover /Land use	**I1C**	Distance to growth areas	I2A2	Distance to water bodies	I3A2	Flood risk	I4A2	**Employment density**	**I5C**
Soil	**I1D**	Distance to amenities	I2A3	Catchment areas/coastal area	I3A3	Bushfire risk	I4A3	**Monthly Income per Household**	**I5D**
Soil texture	I1D1	Distance to major urban nodes	I2A4	**Biodiversity**	**I3B**	Landslide	I4A4	**Special protection area (Heritage lands)**	**I5E**
Soil Depth	I1D2	Others	I2A5	Protected areas	I3B1	**Exposure to other hazards**	**I4B**	Distance to historic sites (Preservation)	I5E1
Erosion severity	I1D3	**Utility Attributes**	**I2B**	Natural features	I3B2	High tension line	I4B1	Historic corridor (Heritage)	I5E2
other	I1D4	Water network	I2B1	**Others**	**I3C**	Explosive	I4B2		
Climate	**I1E**	Drainage network	I2B2	Air Pollution/quality	I3C1	Mining	I4B3		
Precipitation	I1E1	River and Drainage Density	I2B3	Noise pollution	I3C2				
Temperature	I1E2	**Economic attributes**	**I2C**						
Relative humid	I1E3	Land Value	I2C1						
Wind speed	I1E4	Ownership status	I2C2						
Aspect	**IF6**								

2.5.2 Tools and methods

Tools and methods are also an important part of land suitability analysis. To carry out an analysis of these indicators different tools and methods need to be adopted which can provide more accurate output so that it can help in planning for green development and better urban growth.

After reviewing the research papers and review papers, it was observed that certain tools and methods were used in many studies as they provide satisfactory output, and further development on the given output will result in more sustainable growth, whereas certain tools are not used in many studies and are used only in one or two studies because they are more complicated in use and also there was lack of data needs to be used to carry out analysis by those tools and methods

Tools and methods have been studied from various studies earlier there were 11 themes in which the tools and methods were divided and has 97 tools and methods, whereas after clubbing certain tools and methods under different themes it has been reduced to seven themes and 62 tools and methods and further it is divided in sub- methods and tools which are 44 in number. This will help in analysing different methods and tools. So, this analysis will provide the most utilized tools and methods which can further be taken up into study.

Themes	Tools/methods	Sub-division of Tools/methods
7	62	44

A. Tools and methods which are used maximum in studies

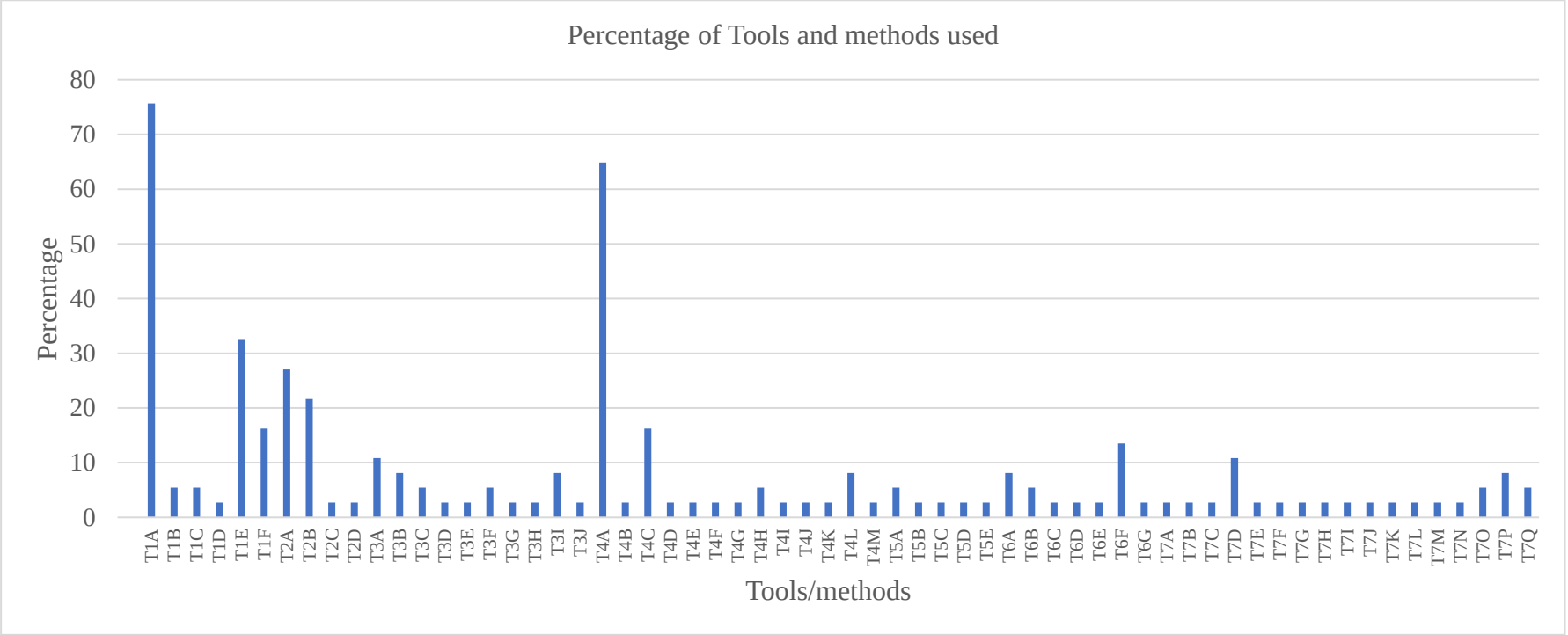

Percentage of Tools and methods used
Percentage
80
70
60
50
40
30
20
10
0
T1A T1B T1C T1D T1E T1F T2A T2B T2C T2D T3A T3B T3C T3D T3E T3F T3G T3H T3I T3J T4A T4B T4C T4D T4E T4F T4G T4H T4I T4J T4K T4L T4M T5A T5B T5C T5D T5E T6A T6B T6C T6D T6E T6F T6G T7A T7B T7C T7D T7E T7F T7G T7H T7I T7J T7K T7L T7M T7N T7O T7P T7Q
Tools/methods

Figure 7 Tools and methods percentage of usage in different studies

From various studies tools and methods were identified, further it was analysed on the basis of usage of the methods or tools in different studies. On the basis of the analysis few tools and methods which are used mostly have been identified for land suitability analysis (ref. to fig. 7 & 8; table 5).

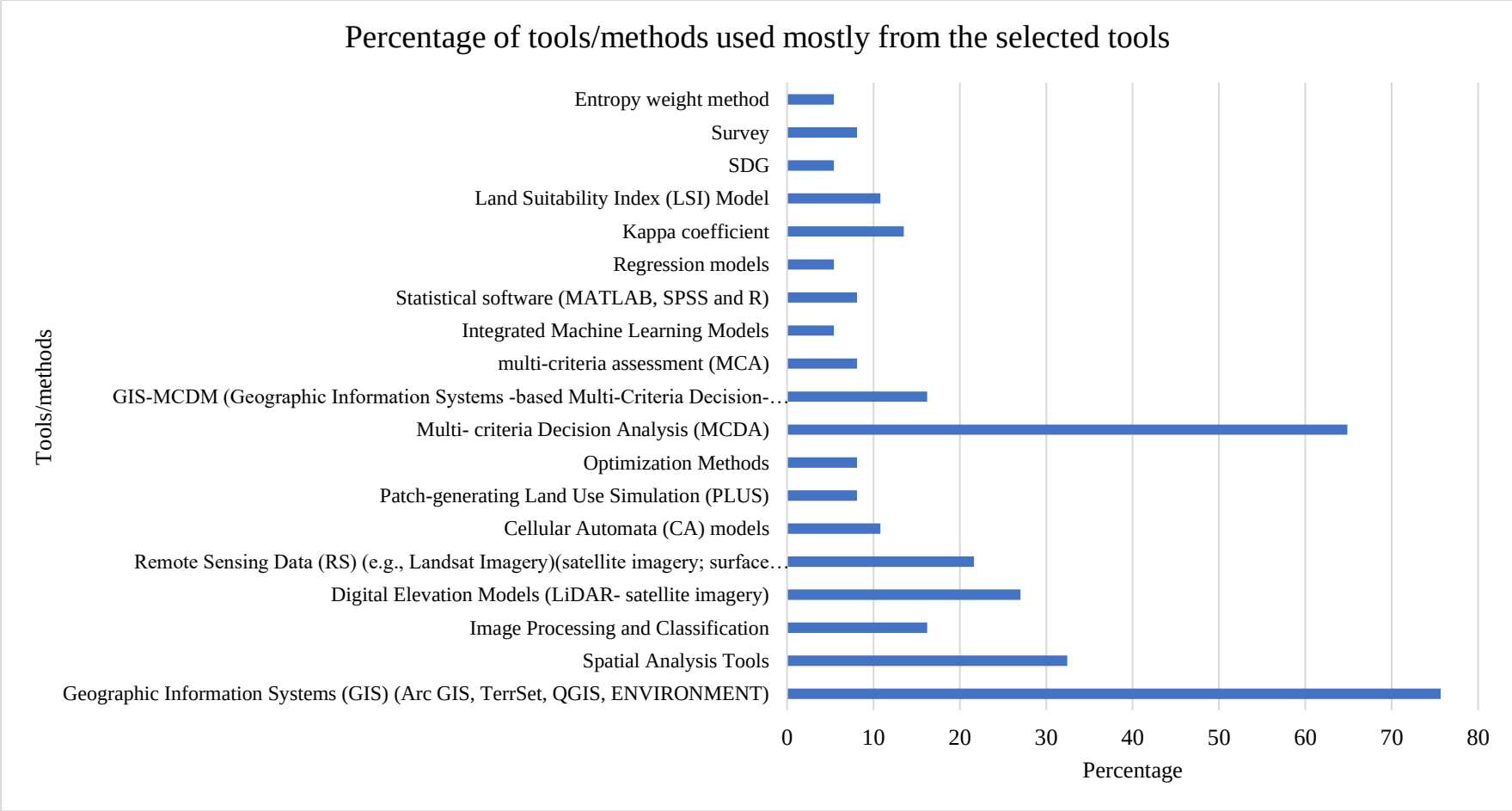


Figure 8 Tools/methods under selected tools/method

Table 5 Tools and method mostly used in studies

Tools and Methods	
GIS Software and Tools	**Scenario-decision Analysis**
Geographic Information Systems (GIS) (ArcGIS, TerrSet, QGIS, ENVIRONMENT)	Multi- criteria Decision Analysis (MCDA)
Spatial Analysis Tools	GIS-MCDM (Geographic Information Systems -based multi-criteria Decision-Making)
Image Processing and Classification	multi-criteria assessment (MCA)
Remote Sensing Data and Tools	**Machine Learning and AI**
Digital Elevation Models (LiDAR- satellite imagery)	Integrated Machine Learning Models
Remote Sensing Data (RS) (e.g., Landsat Imagery) (satellite imagery; surface condition)	**Statistical Methods**
Land Use/Land Cover Modelling	Statistical software (MATLAB, SPSS and R)
Cellular Automata (CA) models	Regression models
Patch-generating Land Use Simulation (PLUS)	Kappa coefficient
Optimization Methods	
Others	
SDG	Land Suitability Index (LSI) Model
Survey	Entropy weight method

2.6 Case studies

Four case studies (table 6) have been examined to understand how land suitability analysis aids planning and addresses urbanization issues. Analysis highlights appropriate areas of urban development, hence reducing urban sprawl. Analysis also demonstrates how combining land suitability with planning guides policies, assists in urban renewal, and directs the development. The researchers improve knowledge of choosing proper indicators, tools, and methods for analysis, and gathering and making use of data to select proper land for development without disrupting ecological balance. Comparison of the case studies have been done for better understanding of what indicators, tools and methods have been used.

Table 6 Comparative analysis of case studies

Case study	**Ili Valley, China**	**Bendigo, Australia**	**Yau Tsim Mong district, Hong Kong, China**	**Land-use suitability analysis for urban development in Beijing**	
Parameters used	Topographic and geologic factors;	Topography;	Inherent/physical attributes	Opportunity	Constraints
			Locational attributes (accessibility)	Topography	Restrictive factors
			Social attributes	Geology	Prohibitive factors
	Ecological factors;	Transport;	Economic attributes	Socio-economic	
	Socio-economic factors;	Natural disaster;	Environmental attributes		
			Political/legal factors		
	Prohibitive factors;	Socio-economic;	Community/cultural factors		
Tools used	GIS-MCDA (LSP+OWA)	GIS-MCE (Boolean and weighted overlay)	GIS-MCDA	Multi-criteria Evaluation (MCE); Ideal Point Method (IPM); Ordered Weighted Averaging (OWA); Analytical Hierarchical Process (AHP)	
Aim	To evaluate the suitability of land for urban development in the Ili Valley using Geographic Information System (GIS) techniques combined with soft computing methods.	To evaluate and identify suitable land for urban development.	To develop a GIS-based framework that supports land use planning in urban renewal projects	to assess the suitability of land for urban development in Beijing, utilizing a systematic approach that integrates various opportunity and constraint criteria.	

Main objective	To cater to city sprawling. To provide a robust framework for decision-making in urban planning, particularly in rapidly developing regions.	Guidance recommendation; Policy oriented; Comprehensive analysis that assists policymakers and urban planners in making informed decisions regarding land-use planning.	Urban renewal planning	Land-use suitability analysis for urban development and also to ensure the ecological balance with urban development through MCE which considers both opportunity and constraint factors. analysis is crucial for effective urban planning in mega-cities like Beijing, where rapid urbanization poses significant challenges.
Level	Regional level	Regional level	City level	City level
Developed/ Developing	Developing	Developed	Developing	Developing
Remark	GSC (GIS-based soft computing) approach provides more accurate results and more alternative decision scenarios, both of which are useful for making practical decisions.	The suitability analysis makes urban planning decision-making more rational. Two sites were selected for future development.	Land use planning is crucial for achieving sustainable urban development. However, one significant challenge that planners often face is the lack of an integrated quantitative method for evaluating land-use suitability and aiding land use planning at the site level, especially in the context of urban renewal.	The OWA approach provided more accurate results given its rational basis, and so is useful for providing practical decisions. From analysis it has been observed that few land parcels are developed on not suitable areas and need to be replanned.

2.7 Summary

This chapter offers an overview of important terminologies concerning land, urban, and green development and is the foundation for further study of the topic. It discusses the definition and importance of land suitability and its strategies, approaches, policies, and acts for land use planning. It addresses different indicators under diverse themes that are important for city development, highlighting the need to choose appropriate indicators, e.g., physical, socio-economic, and environmental factors for efficient land suitability analysis, particularly in organized and sustainable peri-urban development.

Furthermore, the chapter discusses a series of analysis methods and tools and, notably, the necessity to choose approaches suitable to available data as well as to required accuracy. Such methods as Multi-Criteria Decision Analysis (MCDA) and the Analytic Hierarchy Process (AHP) are mentioned as being excellent with their capability to combine a lot of variables in order to boost urban planning decisions. Through case studies, the chapter demonstrates that integration of land suitability analysis makes it possible for the planners to accurately define areas for urban sprawl, agriculture, and parkland. The method is significant in maximizing land use, maintaining ecological stability, and increasing quality of life. The chapter concludes by highlighting the need for the selection of indicators and the precision of the analyses in achieving sustainable land management.

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CHAPTER-3 CITY SELECTION

The chapter covers the criteria used for selecting the city and provides an overview of the chosen city, including basic information. It also discusses the relevant policies associated with the city or state.

3.1 City selection process

To select a city for the study, it is necessary to set some criteria in line with the goals of the study. The criteria ensure that the selected city is appropriate and relevant to answer the research questions or problems under consideration. Criteria such as the size of the city, level of urbanization, data availability, socio-economic profile, and prevailing urban planning problems can be taken into consideration while making the choice. By careful consideration of these factors, selection of a city where the findings of the study will be most relevant and beneficial. After the city is selected on these clearly defined criteria, the research may then go on to examine and address the particular urban challenges or opportunities in the context, yielding more targeted and useful recommendations.

The city selection is an important part, so for that few criteria have been listed:

- Tier II city
- Urban Area
- Rapid Growth rate
- Green Cover loss
- Conversion of Agricultural land to non-agricultural land

Why tier II cities?

Tier II cities are rapidly growing and attracting investment, offering an alternative to congested Tier 1 cities. Strategic planning in these cities is key to sustainable growth, enabling them to manage increasing populations and meet evolving needs effectively.

Among various Tier II cities, only capital cities were taken into account because of their importance within their respective states. Out of the initial list of eight cities, two cities were in coastal areas. Since the study considers a plain city, both these cities were excluded, resulting in six cities. Comparing growth rates, Raipur and Bhubaneswar came at the top. But since Raipur is already planning Naya Raipur to address future needs, it was decided to focus on Bhubaneswar, the second-highest developing city, for study. Also, various studies have recognized issues in Bhubaneswar like uncontrolled urbanization, green space loss, and land conversion, making it a suitable case for study.

Over the past 15 years, Bhubaneswar, the tier-II capital city of Odisha, has undergone drastic changes in land cover and land use, primarily attributed to the over-exploitation of natural resources and the accelerated rate of urbanization. Urban expansion has created an 83% increase in urban space, drastically changing the face of the city and facilitating the rapid urbanization of natural ecosystems into urbanized landscapes. As a result, there has been a shocking 89% decline in dense cover and an 83% loss of crop fields, with the expansion of the city being most pronounced towards the South, Southwest, and North [32]. This unchecked urban sprawl has not only heightened Bhubaneswar's vulnerability to climate change but also contributed to a host of environmental challenges, including housing shortages, declining water quality, increased air and noise pollution, dust, heat stress, and mounting difficulties in waste management [33]. The encroachment on fertile agricultural land further threatens regional food security, as evidenced by a total loss of 18.10 km² of agricultural land between 1991 and 2021-an average decrease of 0.06 km² per year [34]. Moreover, provision of urban green space is far below recommended standards; while Indian guidelines suggest 1.4 to 1.6 hectares per 1,000 residents and the NRPA standard requires 4 hectares, whereas Bhubaneswar offers only 0.57 hectares per 1,000 people, highlighting a significant shortfall in recreational and ecological facilities for its growing population [35].

3.2 Bhubaneswar

Bhubaneswar, the capital city of Odisha (in 1948), is located in the eastern zone of India and lies approximately 64 kilometres from Puri, the sacred abode of Lord Jagannath. Together with Puri and Konark, it forms the apex of the renowned 'Golden Triangle' tourist circuit. The city enjoys strong connectivity through road and rail networks linking it to major urban centres within Odisha and neighbouring states. Due to its strategic central location, well-established linkages, pleasant climate, and dynamic growth, Bhubaneswar holds a significant regional position characterized by three key aspects: its role within Odisha state, its status as the capital sub-region, and its place in the Golden Triangle of Tourism. As the state capital, Bhubaneswar functions as an administrative hub and a centre for tertiary economic activities, including services, trade, and commerce [36].

Bhubaneswar not only boasts strong regional connectivity and serves as an economic hub but also has a rich cultural heritage. It is renowned for the Lord Shiva temple complex located in its old city, which features magnificent sculptural and architectural elements

reflecting Odisha's social, cultural, and religious history across various periods. This old city area, known as Ekamra Kshetra, is celebrated as the "Temple City" of Bhubaneswar and comprises a vast collection of ancient sandstone temples, heritage ponds, and monuments [36].

Bhubaneswar Metropolitan Corporation (BMC) is the local urban governing body for Bhubaneswar and the principal provider of services to it. BMC has an area of 186 square kilometres and has a population of around 840834 as per BMC. BMC has 67 wards (fig. 9) [35].

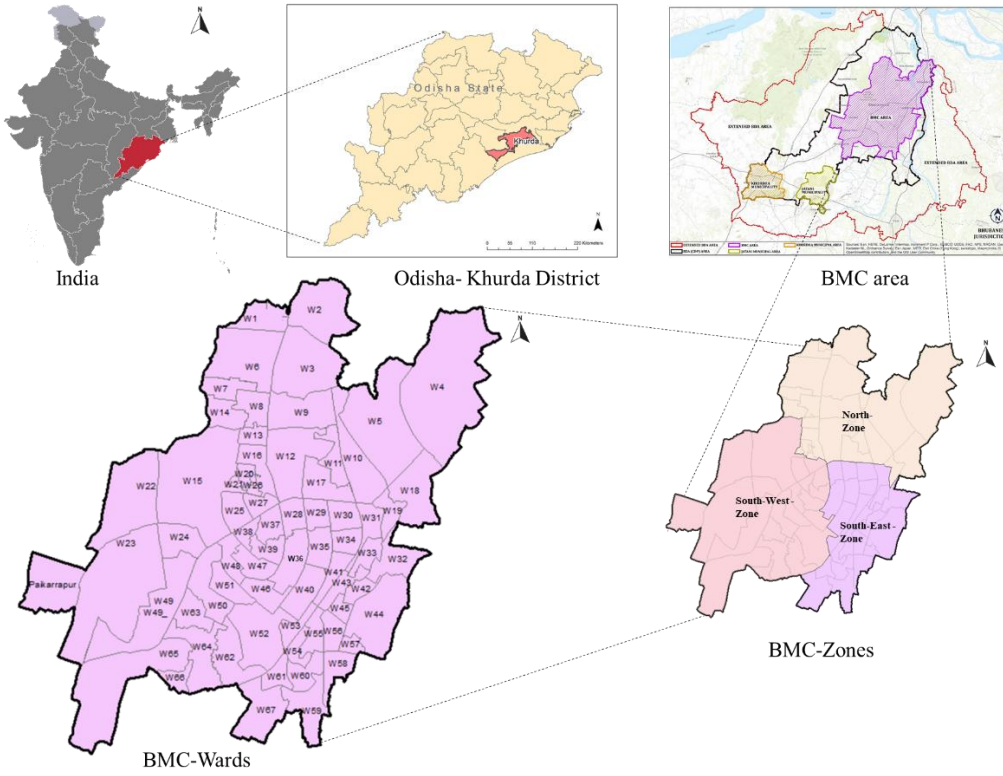


Figure 9 Bhubaneswar city- Location Map

3.2.1 City's Demographic profile

Bhubaneswar city is governed by Municipal Corporation which comes under Bhubaneswar Metropolitan Region. City had a population of 6,48,032 in 2001, and 8,40,834 in 2011. The literacy rate (%) of the city as per census 2011 was 91.89% [37].

According to the 2011 Census, population data is available; however, for further analysis, the population has been projected using the Geometric Progression Method, which assumes a constant rate of population growth over time.

Formula: $[Pn = (1 + IG / 100) \hat{} n]$ 1

where, IG refers to geometric mean (%), Pn refers to present population and n refers to the number of decades (table 7).

Table 7 Population Projection

Year	Population	Incremental (Decadal growth)	Decadal growth rate
1981	2,19,211	-	-
1991	4,87,531	268320	1.22
2001	6,48,032	160501	0.32
2011	8,40,834	192802	0.29
2021	12,87,597		
2031	19,71,740		
2041	30,19,391		
2051	46,23,693		

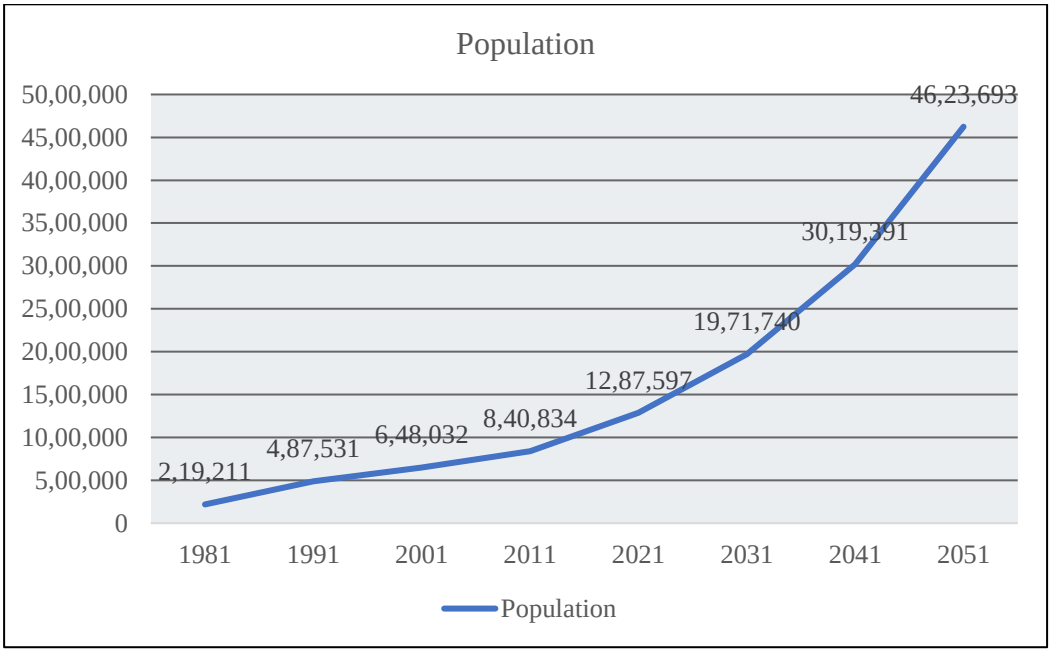
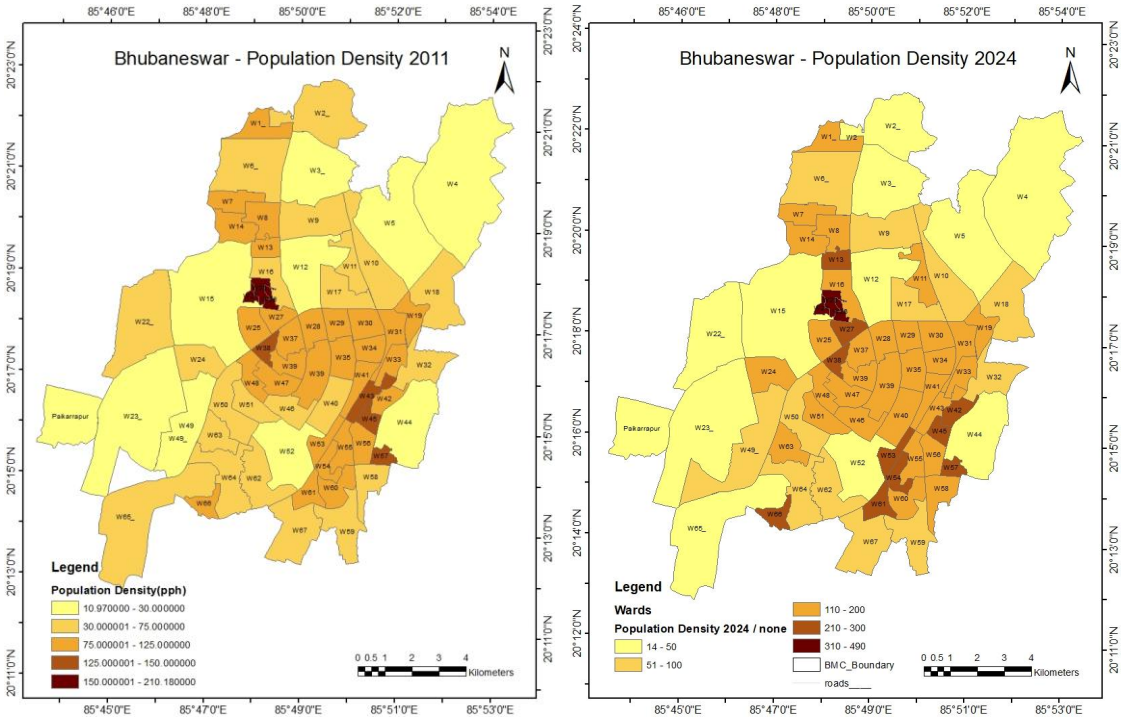


Figure 10 Population Projection

Inference: Bhubaneswar city population projection (table 7, fig. 10, map 1) shows a rapid urbanization indicating that the city has crossed the population over 10 lakh and turn towards becoming tier 1 city.



Map 1 Population density 2011 and 2024

Socio-Economic characteristics

Bhubaneswar functions primarily as an administrative city with sustained growth in tertiary economic activities. Its major economic sectors include trade and commerce, tourism-related activities, and to a lesser extent, industrial activities. The worker participation rate increased from about 33.34% of the total population in 2001 to approximately 35.55% in 2011. The distribution of workers by sector in 2011 was:

- Primary sector: 0.79% (including cultivators and agricultural labourers)
- Secondary sector: 27.92% (covering household industries, manufacturing, services, and repair)
- Tertiary sector: 71.29% (comprising trade and commerce, transport, and service sectors).

This reflects Bhubaneswar's dominant service-oriented economy, supported by a growing industrial base including paper, steel, automobile, pharmaceuticals, and electronics industries. Additionally, Bhubaneswar has a traditional handicrafts industry contributing significantly to its economy [36] [37].

Issues and Challenges

Based on the criteria established for selecting the city, an analysis of Bhubaneswar's current situation has revealed several key challenges and issues (fig. 11).

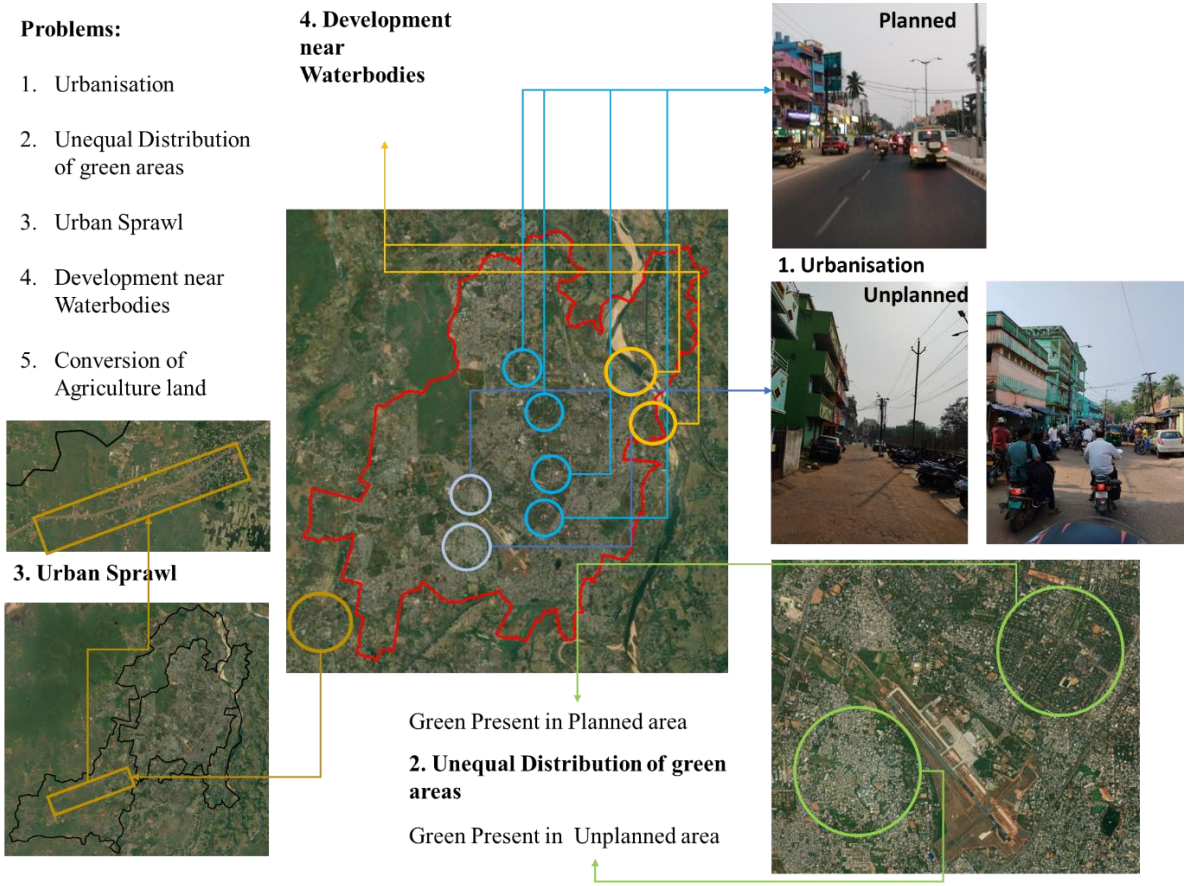


Figure 11 Identified problems

- Rapid urbanization in Bhubaneswar has resulted in unplanned development, despite the city's original planned design.
- Unplanned growth has led to several challenges, including:
- Unequal distribution of green spaces-planned areas has ample greenery, while unplanned areas lack sufficient green zones.
- Significant development occurring near water bodies, raising environmental concerns.
- The increasing demand for land to accommodate a growing population has triggered urban sprawl.
- There has been a noticeable conversion of agricultural land to non-agricultural uses to support development.
- To address these issues, it is essential to thoroughly analyse existing land use and plan future development more systematically.
- Proper land analysis and planning can help maintain environmental balance alongside urban growth.

3.3 Policies/Schemes in Odisha

Here, policies and schemes in Odisha and Bhubaneswar have been discussed (table 8):

Table 8 Policies/Schemes in Odisha

Name	Description
Policy for Housing for All in Urban Areas, Odisha (2015/2022) [38][39]	Aim is to create affordable housing for vulnerable sections of society while ensuring overall urban quality improves.
Bikashita Gaon, Bikashita Odisha (BGBO) [40]	Odisha government has introduced the "Bikashita Gaon Bikashita Odisha" (BGBO) scheme to undertake sustainable development projects for inclusive growth in rural areas of Odisha. (2025) The Biju Janata Dal government started the 'Ama Gaon Ama Bikash' (AGAB) (2018) scheme to accelerate local development through small and essential projects of local importance and providing missing links to existing development infrastructure.
Rajiv Awas Yojana [41]	Rajiv Awas Yojana (RAY) for the slum dwellers and the urban poor envisages a 'Slum-free India' through encouraging States/Union Territories to tackle the problem of slums in a definitive manner. Objective: Tackling the shortages of urban land and housing that keep shelter out of reach of the urban poor and force them to resort to extra-legal solutions in a bid to retain their sources of livelihood and employment.
Go Green Drive [42]	The environmental problems in Bhubaneswar are growing rapidly with the increasing economic development and a rapidly growing population. Industrial pollution, soil erosion, deforestation, rapid industrialization, urbanization, and land degradation are all worsening problems.

	"Go Green" is the resolve to “infect the whole of Bhubaneswar with the will to change towards a greener future". Encouraging 3Rs (Recycle, Reduce, Reuse) Bhubaneswar City's Renewable Energy & Energy Efficiency Policy.
Mo Jami Mo Diha, 2007	Aim: land revenue management and ensuring proper documentation of land records. This initiative focuses on updating land records and providing clear titles to landowners, enhancing security of tenure.
Rehabilitation and Resettlement Policy, 2025 (proposed) [43]	The Odisha government is set to introduce a comprehensive Rehabilitation and Resettlement Policy aimed at assisting those displaced by industrial and infrastructure projects. This new policy features a land-for-land compensation approach, allowing displaced farmers to receive land parcels instead of cash compensation, thereby enabling them to continue their agricultural practices. This marks a significant shift from the previous cash-based compensation system established in 2006
Town Planning Scheme [44] [45]	To promote systematic urban growth and development across cities in Odisha. Landowners can hand over their land to the Bhubaneswar Development Authority (BDA), which redevelops the area with necessary infrastructure (roads, sewerage, drainage). After redevelopment, 60% of the land is returned to the owners. Aim is to increase the percentage of planned urban areas from 17% to 30% by 2036.

3.4 Summary

This chapter outlines the selection criteria for the city. It explores the city’s historical significance and investigates its population trends, projecting future changes for further study. It also details the city’s socio-economic profile and examines relevant policies at the state and city levels. Overall, the chapter clarifies the basis for selecting the city, identifies critical considerations, and provides necessary background context.

CHAPTER-4 DATA COLLECTION AND ANALYSIS

This chapter presents the indicators chosen from the final list in Chapter 2, which will be used as the foundation for carrying out the land suitability analysis. Based on these indicators, the analysis determines areas that are suitable or not suitable for development, thus informing more sustainable urban planning. Furthermore, the city's carrying capacity has been evaluated to offer a holistic view of the city as it is today and also to determine where deficiencies lie, such as those pointed out by issues already determined (see chapter 2) and even master plan appraisals is conducted to determine areas where land use percentages are lacking. Through the incorporation of results from land suitability analysis, masterplan, and carrying capacity study, this strategy provides a direction to tackle the challenges of the city and foster sustainable development.

4.1 Selected Indicators and Tools for study

For optimizing the utilization of land, one strategy that needs to be integrated in planning is Land suitability analysis. For this analysis, a range of indicators was identified from various research studies (see Chapter 2), and from that comprehensive list, 18 key indicators (refer to Table 9) were selected and categorized under different themes, which are important for urban development, to guide the analysis. Additionally, various tools and methods were employed to process the data and generate maps for each indicator, as detailed in Table 10.

Table 9 Indicators for the study

Themes	Indicators	Data Required	Data Source
Natural asset (I1)	Terrain elevation (I1A)	DEM	USGS
	Slope (I1B)	DEM	USGS
	Land cover (I1C)	LANDSAT 8 imagery	USGS
	Soil (I1D)	FAO- Digital Soil Mapping and Assessment (DSMA)	FAO
	Climate (I1E)	LANDSAT imagery	USGS
	Aspect (I1F)	DEM	USGS

Strategic planning (I2)	Accessibility (I2A)	Open street map	GIS, QGIS, Google Earth
	Utility Attributes (I2B)	Network map	Bhubaneswar Municipal Corporation (BMC); Bhubaneswar Development Authority (BDA);
	Economic attributes (I2C)	Price Inventory	Inspector General of Registration Revenue & Disaster Management Department (IGR) Odisha portal's "Benchmark Valuation" and Survey.
Ecological and environmental factors (I3)	Hydrology (I3A)	DEM	USGS
	Biodiversity (I3B)	LANDSAT 8 imagery	USGS
	Others (I3C)	Data inventory	State Pollution Control Board, Odisha; Central Pollution Control Board; Survey;
Prohibitive factors (I4)	Exposure to other hazards (I4B)	High tension line map	Bhubaneswar Municipal Corporation (BMC); and Bhubaneswar Development Authority (BDA);
Social Attributes (I5)	Population density (I5B)	Census data	Census;
	Special protection area (Heritage lands) (I5E)	List of monuments under ASI or protected areas	Bhubaneswar Municipal Corporation (BMC); and Bhubaneswar Development Authority (BDA); ASI;

Table 9 provides detailed information for each indicator utilized in the study, including the specific data required and the respective sources from which this data can be collected.

Table 10 Tools and Methods for study

Tools and Methods	
GIS Software and Tools	**Scenario-decision Analysis**
Geographic Information Systems (GIS) (ArcGIS, TerrSet, QGIS, ENVIRONMENT)	Multi- criteria Decision Analysis (MCDA)
Spatial Analysis Tools	
(Overlay mapping, Buffer analysis, Zonal statistics, Euclidean distances, Raster calculator)	**Others**

Image Processing and Classification	Ms Excel
(Image Classification Algorithms: Supervised classification (maximum likelihood and support vector machines); Unsupervised Classification (K-mean clustering), ESRI shape files, LULC Map)	SDG
	Survey
Remote Sensing Data and Tools	
Digital Elevation Models (LiDAR- satellite imagery)	Land surface temperature (LST)
Remote Sensing Data (RS) (e.g., Landsat Imagery) (satellite imagery; surface condition)	Normalized difference vegetation index (NDVI)

4.2 Indicators for analysis

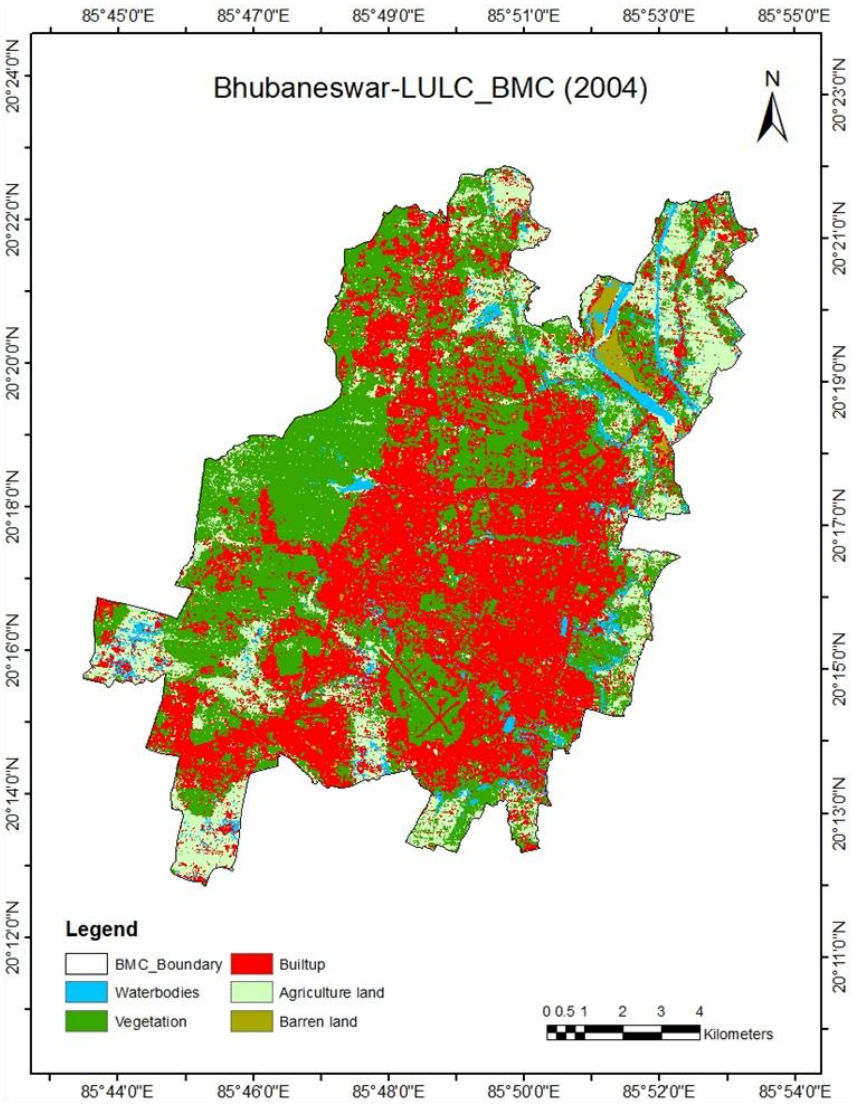
After selecting the indicators for the study, maps for each indicator were generated and organized according to their respective thematic categories.

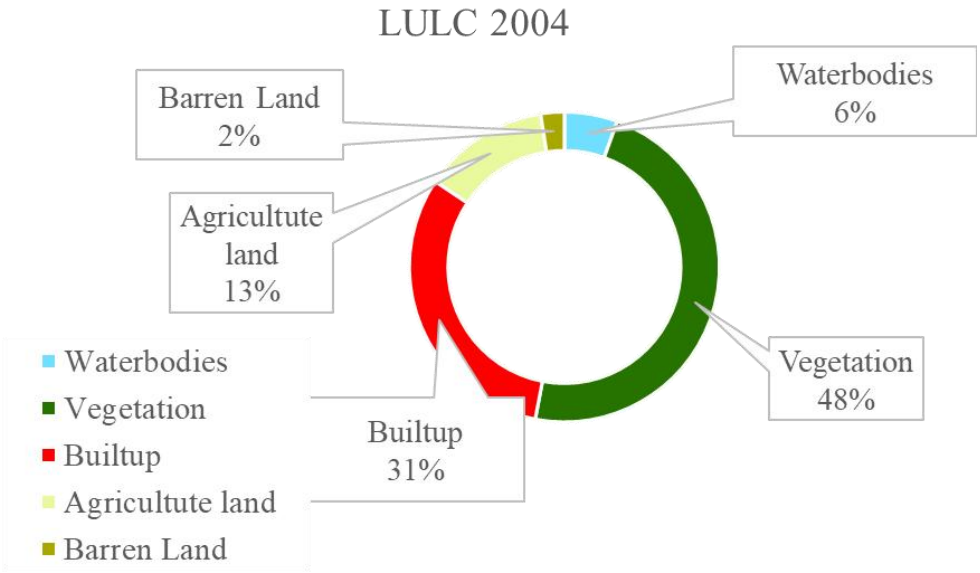
4.2.1 Natural Asset

Indicators under this theme primarily focus on analysing geomorphological aspects, including land cover, slope, elevation, aspect, land surface temperature (LST) for climate assessment, and soil characteristics (maps 2-11).

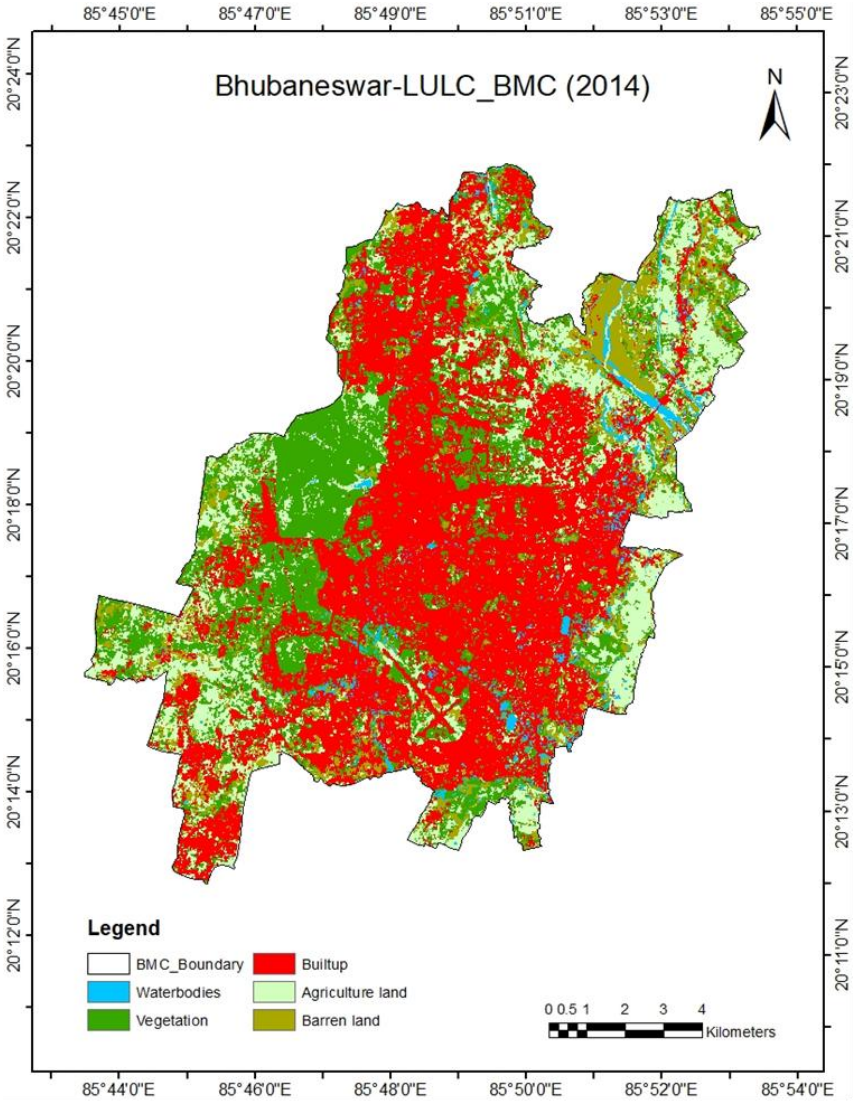
A. Indicator: LULC

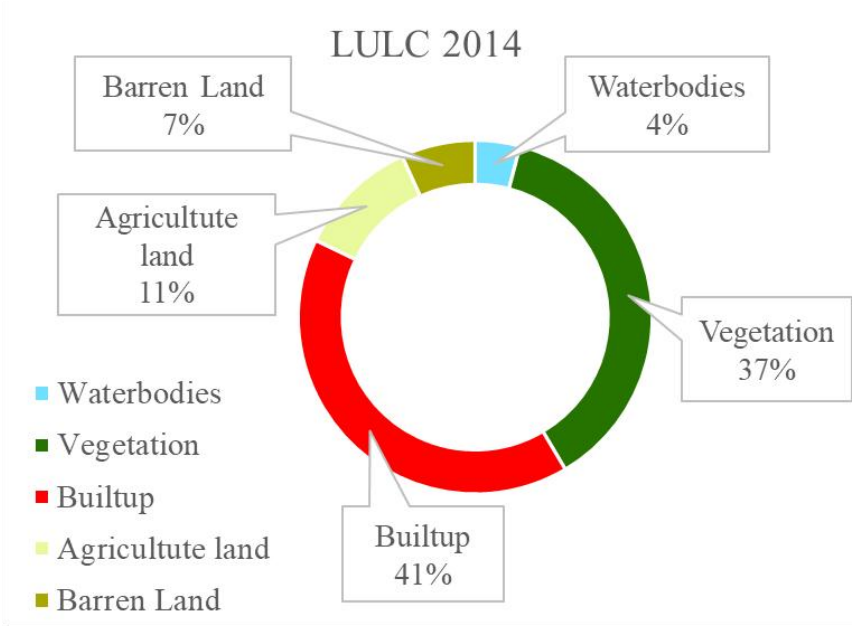
The Land Use Land Cover (LULC) map for the Bhubaneswar Municipal Corporation (BMC) area (map 2,3,4; fig. 12) was generated through GIS-based maximum likelihood classification, categorizing regions into Built-up Areas, Water Bodies, Vegetation, Barren Land, and Agriculture land. Temporal analysis of decadal LULC maps will quantify urbanization rates and assess their environmental impacts by tracking changes in specific land cover types (e.g., vegetation loss, water body shrinkage, or built-up expansion). This approach identifies spatial patterns of urban growth and its cascading effects on ecological systems and agricultural lands within the BMC limits



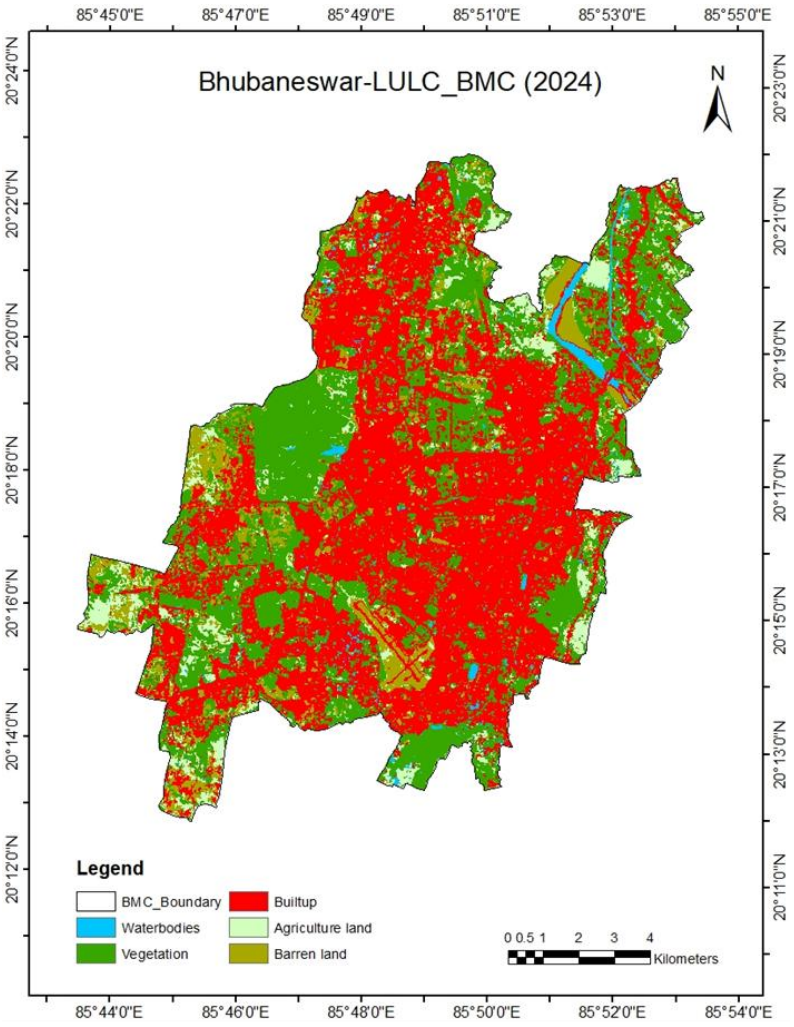


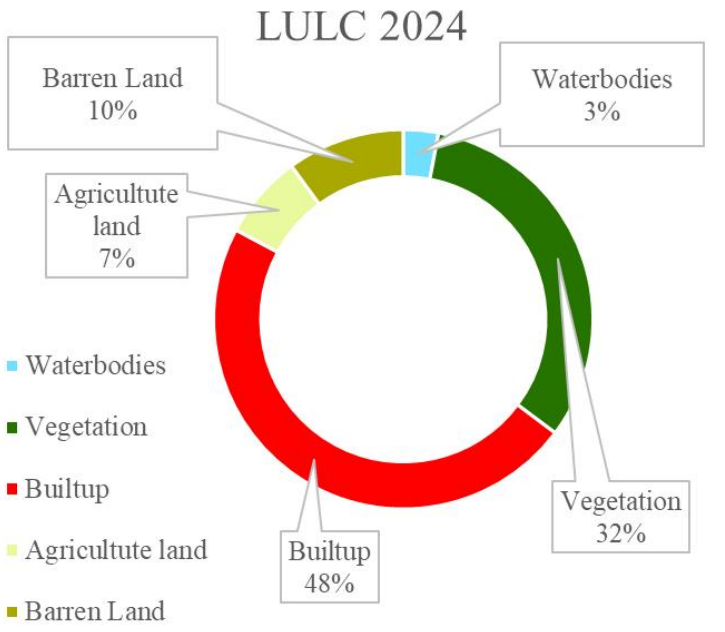
Map 2 LULC map for 2004 -BMC





Map 3 LULC map for 2014 -BMC





Map 4 LULC map for 2024 -BMC

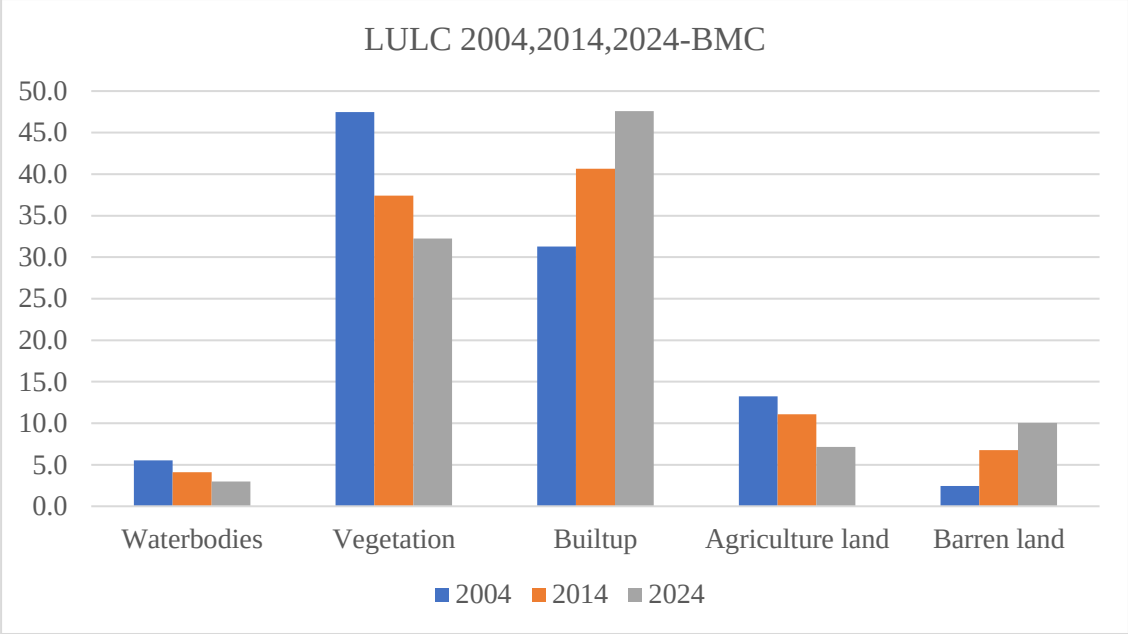
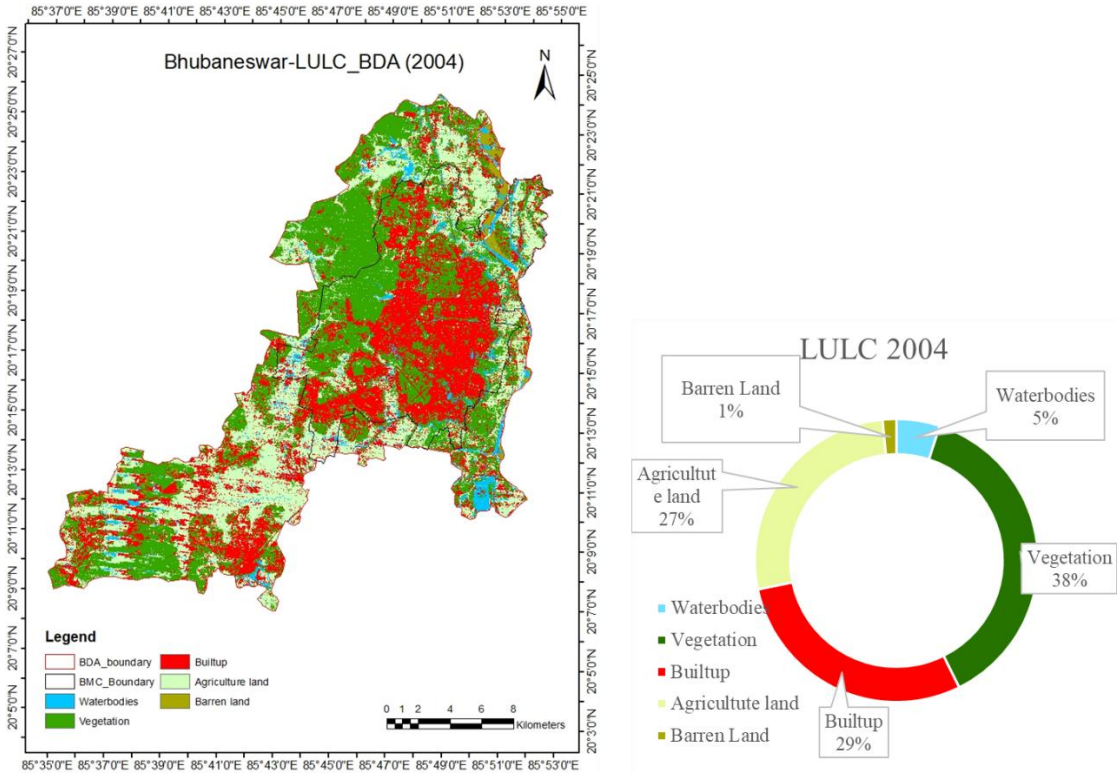


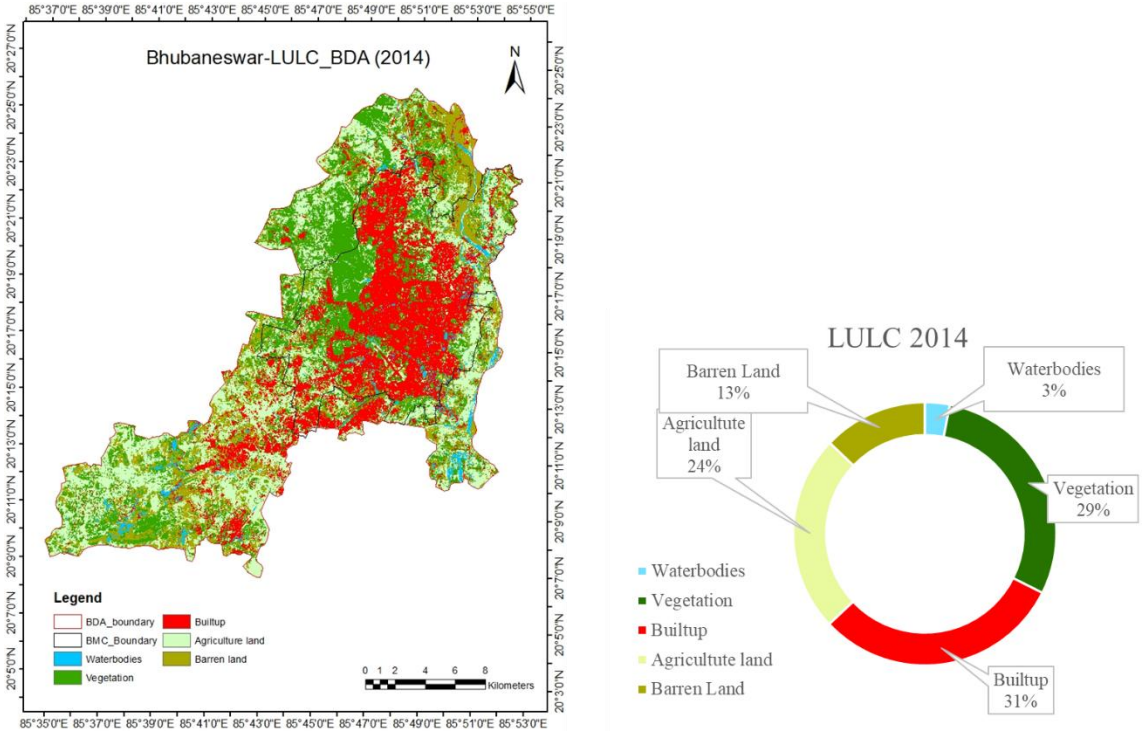
Figure 12 Comparison of LULC -BMC

B. LULC- BDA

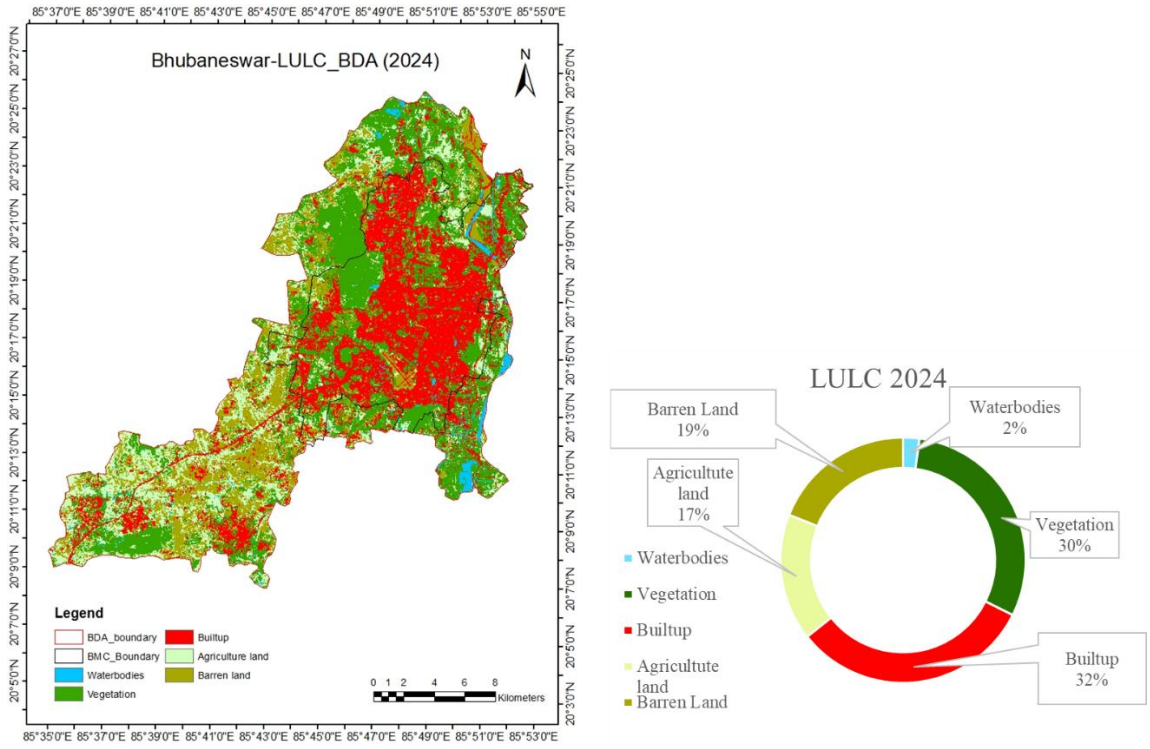
A LULC map for the study area has been made using GIS- maximum likelihood classification. The study area is covering the BDA limits (map 5,6,7; fig. 13). This is a planning area under Bhubaneswar development authority.



Map 5 LULC 2004 – BDA



Map 6 LULC 2014 – BDA



Map 7 LULC 2024 – BDA

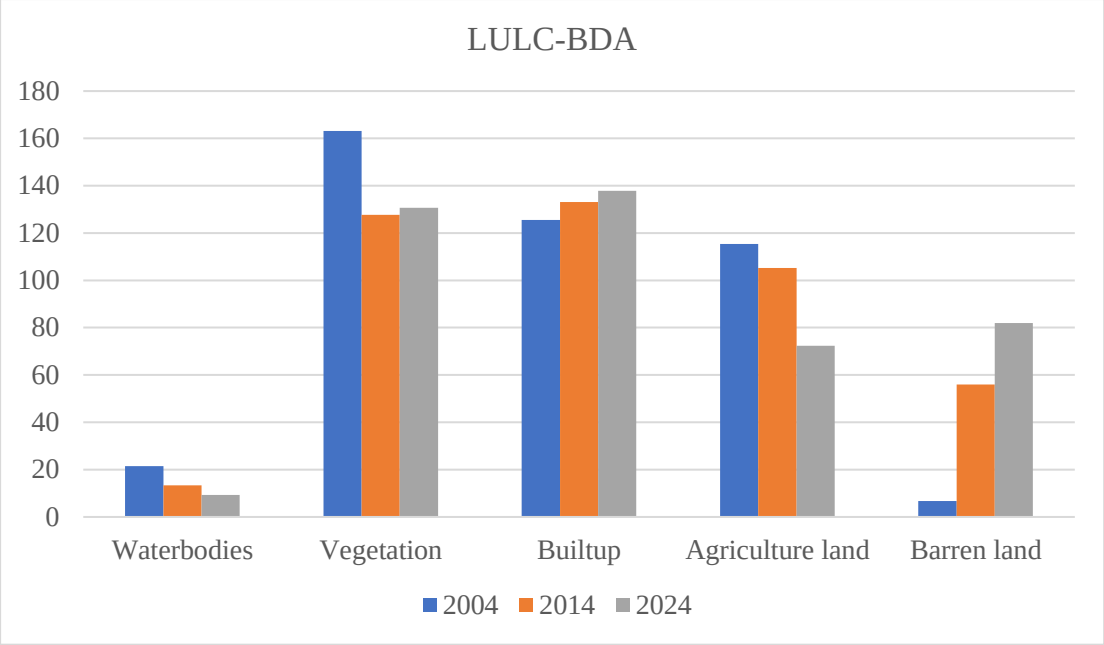


Figure 13 Comparison of LULC -BDA

Inferences:

From the decadal analysis of the LULC maps, the following trends have been observed between 2004 and 2024 (in BMC):

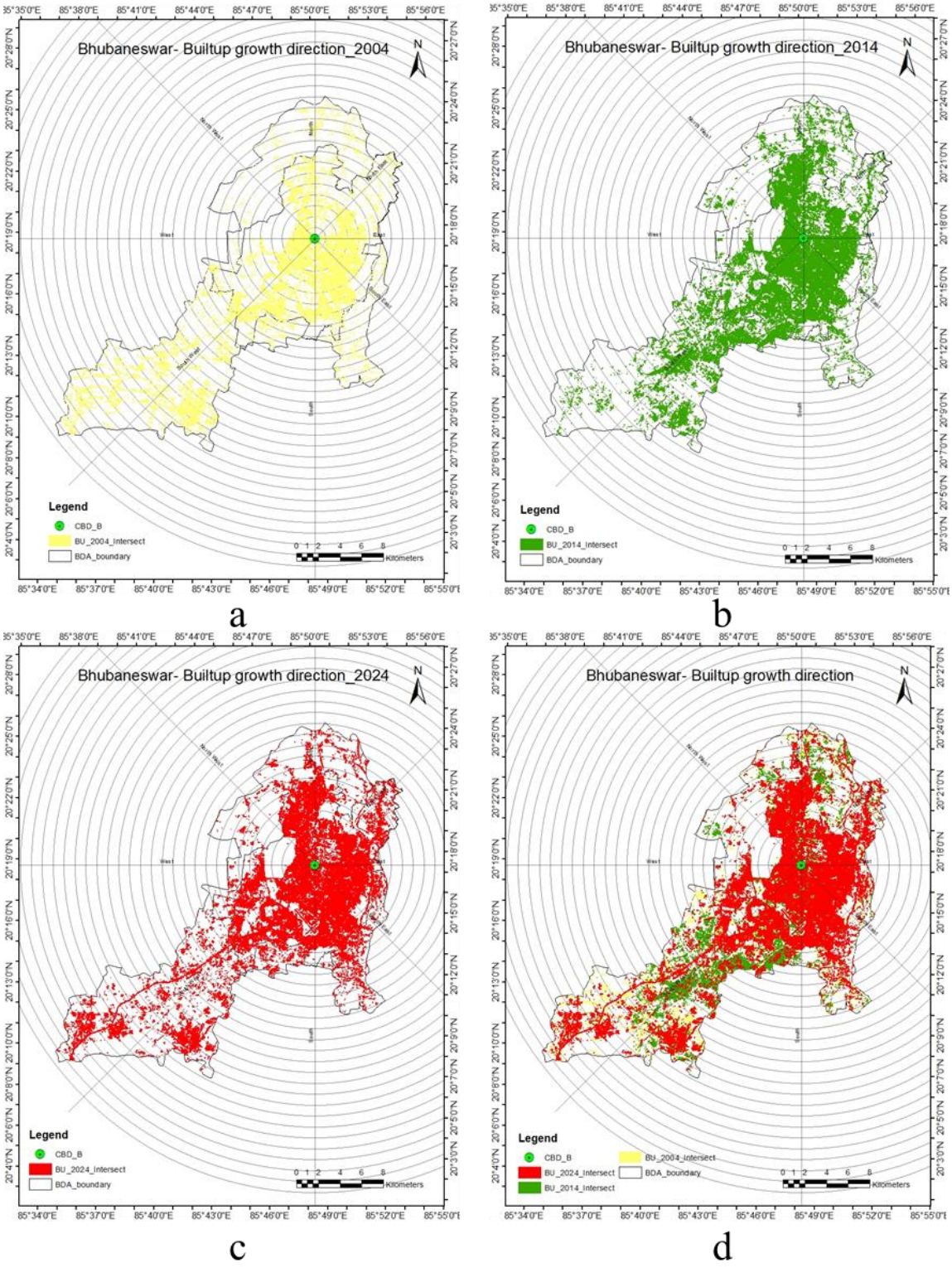
- Built-up areas have increased from 41% to 50%.
- Agricultural land has decreased by 7%.
- Water bodies have reduced by 3%.
- Vegetation cover has declined by 16%.

In the BDA area, the patterns of increase and decrease in land cover types are similar, although the percentages vary:

- Built-up area has grown from 29% to 32% between 2014 and 2024.
- Agricultural land has declined by 10% during the same period.
- Water bodies have decreased by 3% from 2014 to 2024.

Growth- Direction:

After analysing the land covers, the growth pattern and trend were examined by assessing the direction of built-up expansion (map 8, fig. 14). This involved evaluating the increase in built-up areas across different directions, which collectively indicates the predominant direction of urban growth.



Map 8 Built-up- Growth Direction a. 2004, b. 2014, c. 2024, d Combined 2004,2014,2024;

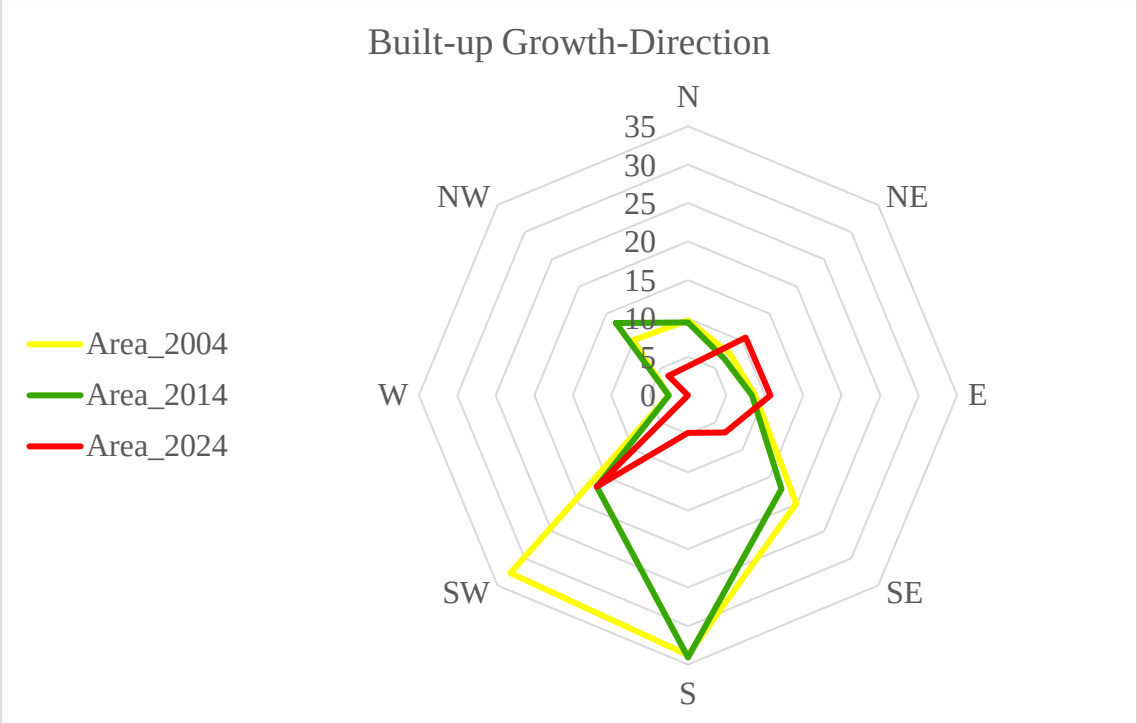
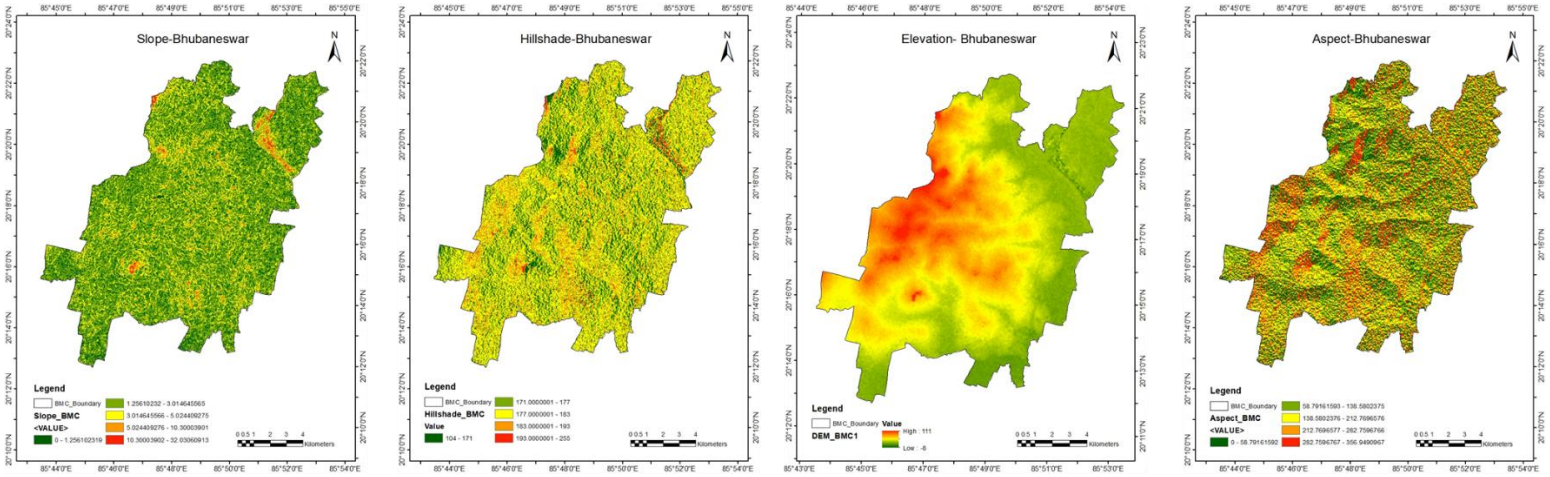


Figure 14 Built-up- Growth Direction of 2004,2014,2024

Analysis:

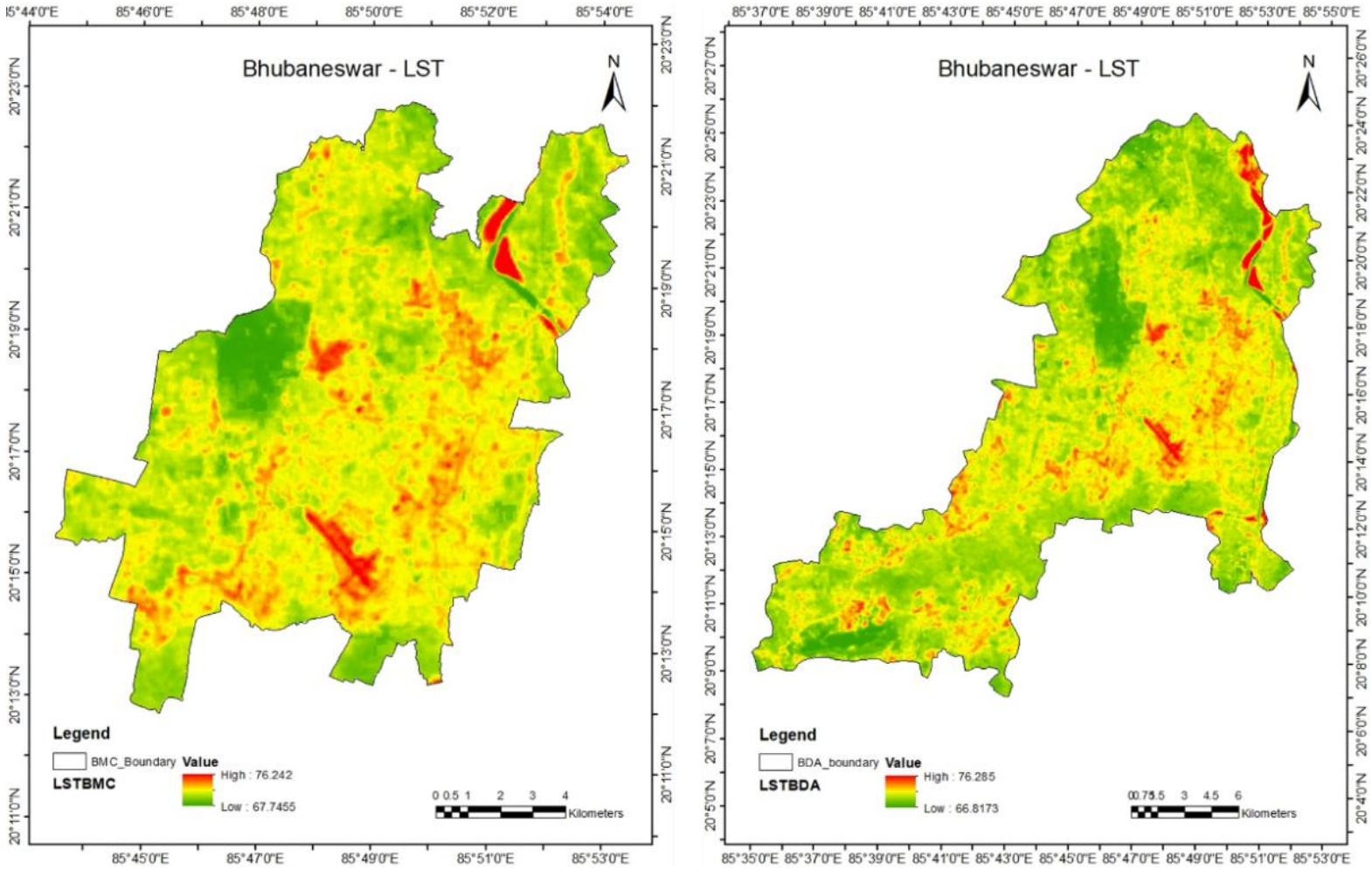
- In 2004, built-up areas were primarily observed toward the South and South-West directions.
- By 2014, built-up growth was mainly concentrated in the South, with some expansion toward the South-East, South-West, and North-West directions.
- Up to 2024, the growth has been predominantly focused on the South-West side, with no significant expansion toward the West.

C. Indicators: Slope, Elevation, Hill shade, and Aspect



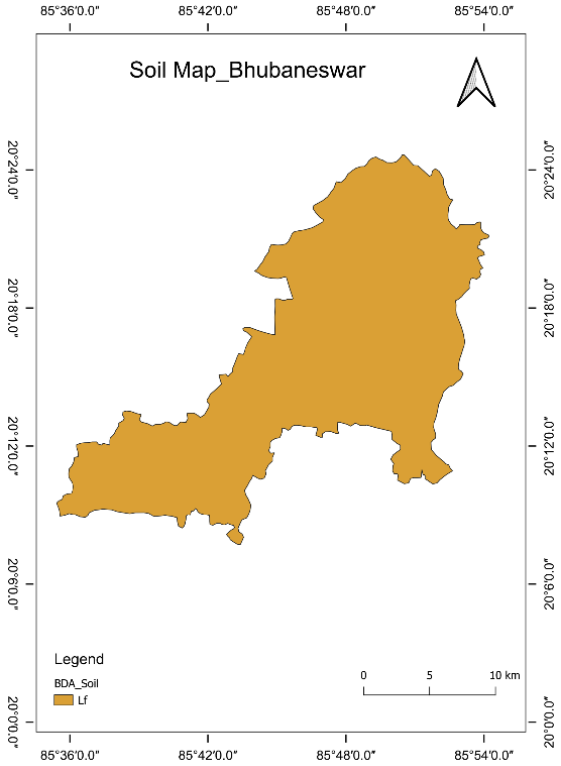
Map 9 Slope, Elevation, Hill shade, Aspect

D. Indicator: Land Surface temperature



Map 10 LST map

E. Indicator: Soil



Map 11 Soil map

Soil Texture- Sandy Loam

Sandy loam soil is a versatile and highly regarded soil type, characterized by a balanced mixture of sand, silt, and clay.

Lf represents Ferric Luvisols (map 11)

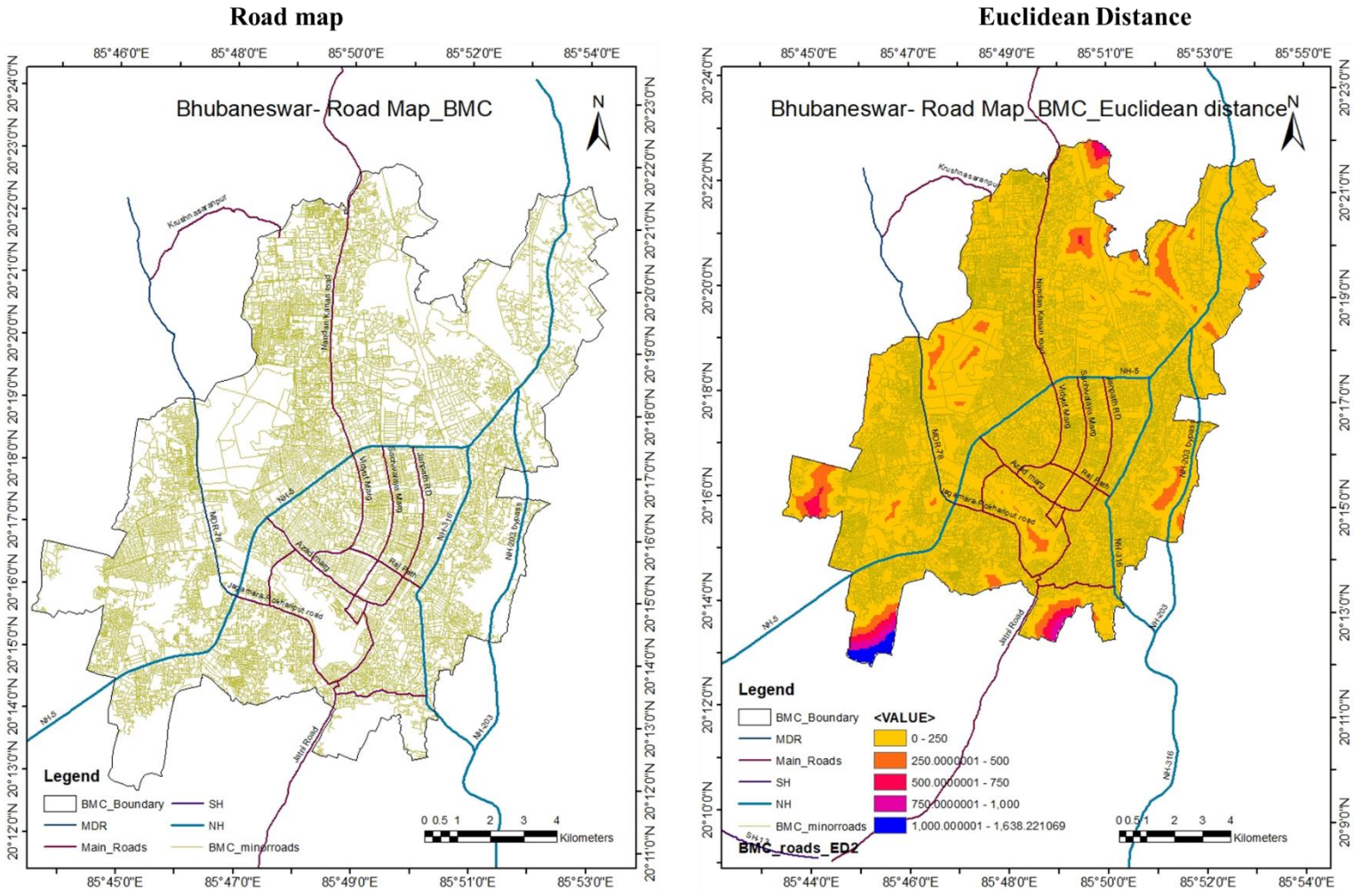
High nutrient content and good drainage properties.

Suitable for various agricultural application (grains, orchards, vineyards)

4.2.2 Strategic Planning

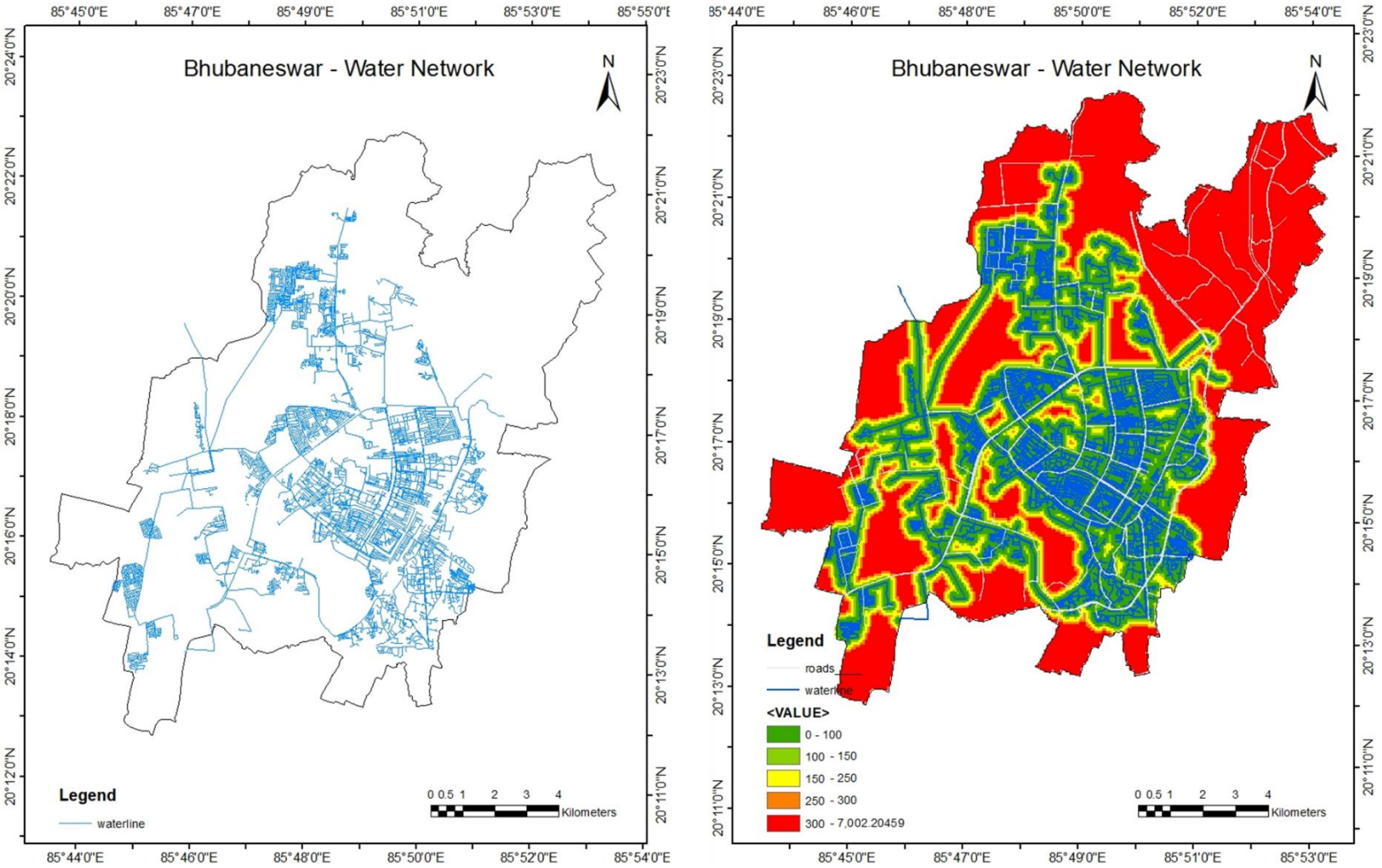
Under this theme, some of the major indicators that strongly affect city development have been covered. Accessibility is a major indicator, as development cannot take place without adequate connectivity. Utility infrastructure-including water supply and sewerage systems-is another essential element; effective access to these essential services facilitates faster urban development and generally generates higher land values. Land price is therefore also a significant indicator since it has direct effects on the overall rate and pattern of city development (maps 12-15).

A. Indicator: Accessibility – Road map



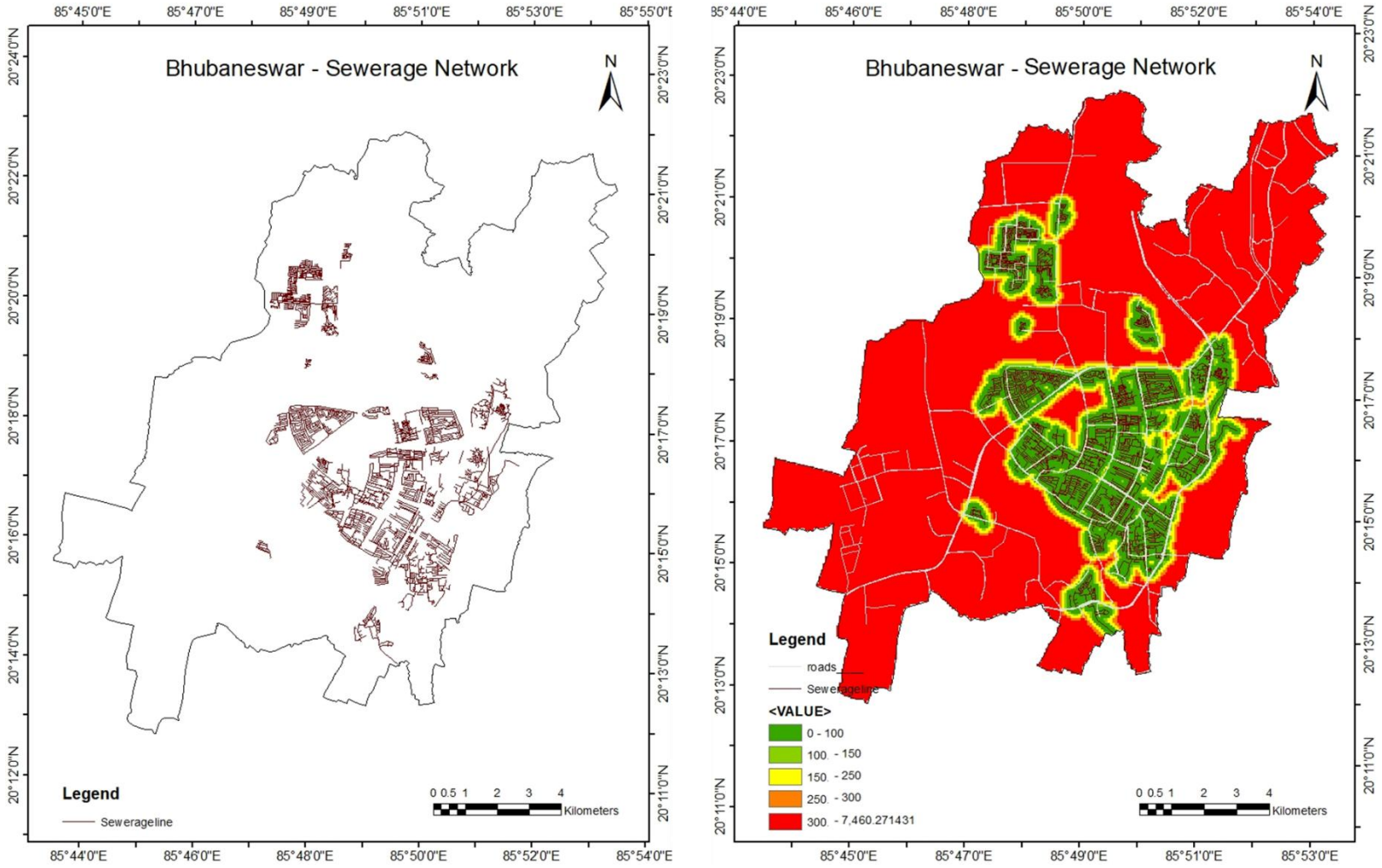
Map 12 Road map and Euclidean distance map of roads

B. Indicator: Utility Attribute – Water Network



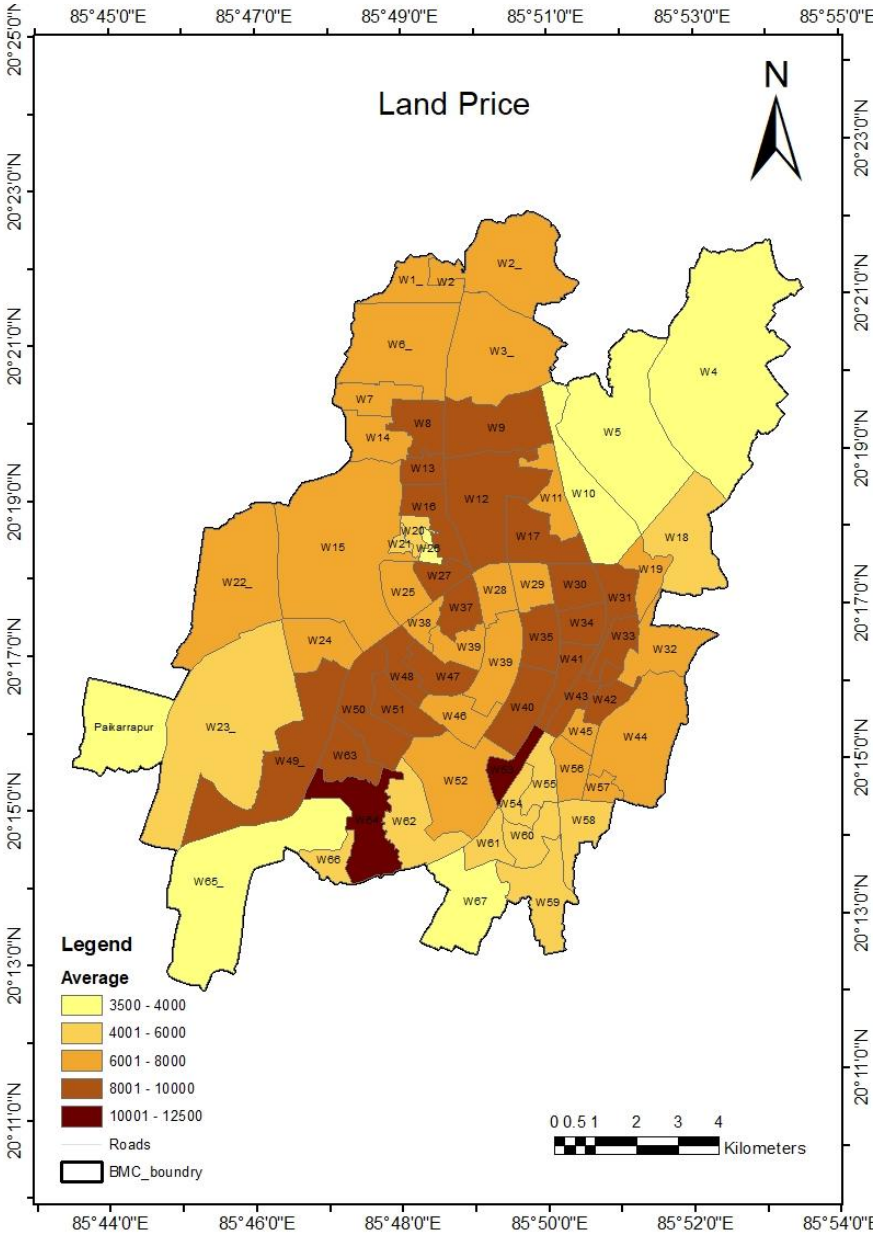
Map 13 Water network map and Euclidean distance map of water network

C. Indicator: Utility Attribute – Sewerage Network



Map 14 Sewerage network map and Euclidean distance map of sewerage network

D. Indicator: Economic Attribute – Land Price



Map 15 Land Price- ward- wise analysis

4.2.3 Ecological and environmental factors

The theme addresses the need to access environmental indicators to maintain ecological balance alongside urban development and to mitigate negative environmental impacts (maps 16-20). The included indicators are:

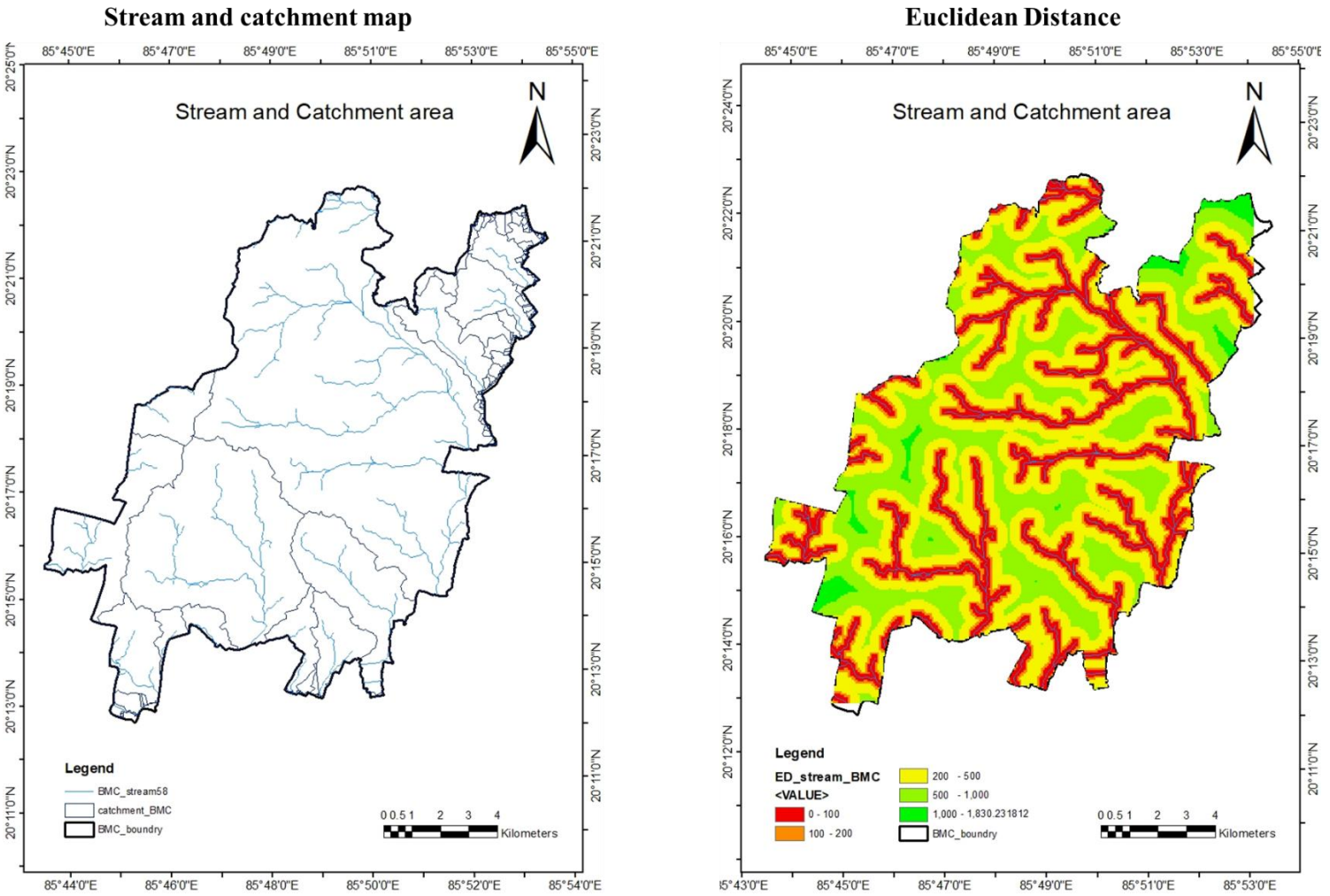
Hydrology: Analysis of streams, catchment areas, drainage density, and groundwater levels to understand water resources and their dynamics (map 16,17,18).

Natural Vegetation: Using NDVI to identify areas with dense vegetation versus shrubs or sparse vegetation, helping to determine suitable zones for development while preserving green cover (map 19).

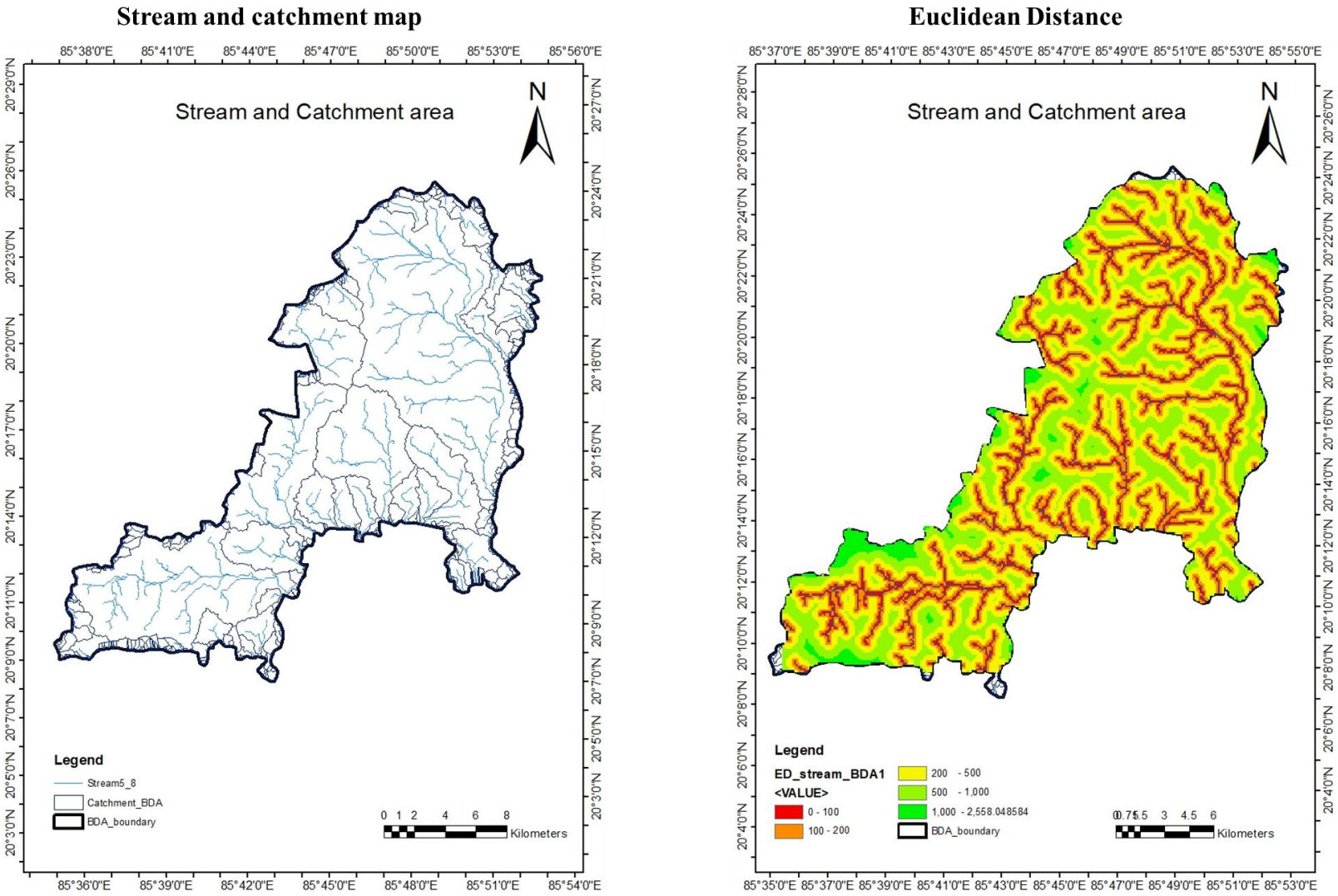
Air Quality Index (AQI) and Noise Levels: These indicators reveal densely populated or industrial/commercial zones, where higher vehicle numbers often contribute to lower air quality. This analysis helps assess the need for green spaces to reduce AQI and noise pollution and guides appropriate land use planning (map 20).

These indicators provide a comprehensive overview to support sustainable urban planning by balancing development needs with environmental conservation.

A. Indicator: Hydrology (Stream and Catchment area)

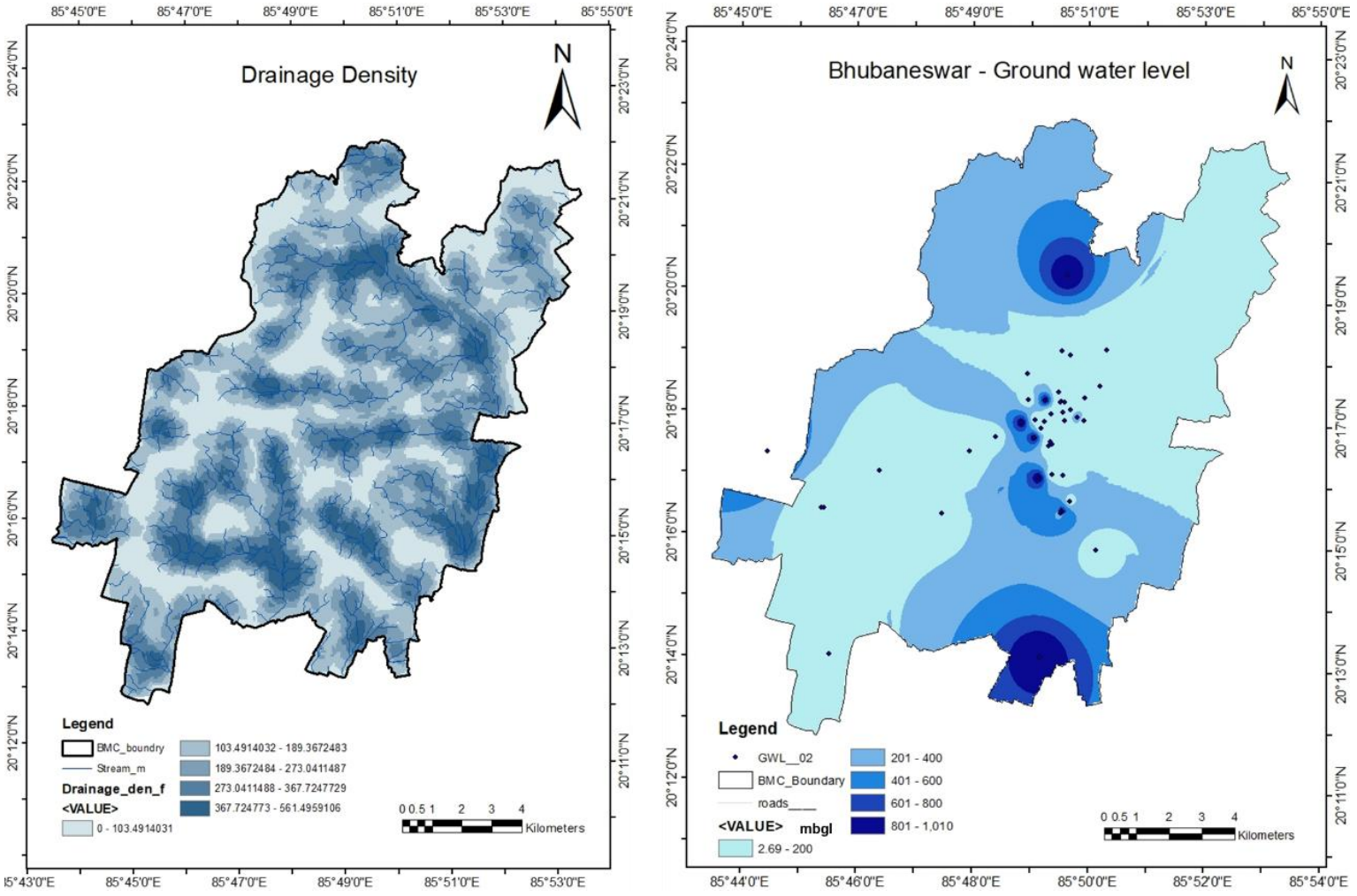


Map 16 Stream and catchment area map and its Euclidean distance map- BMC



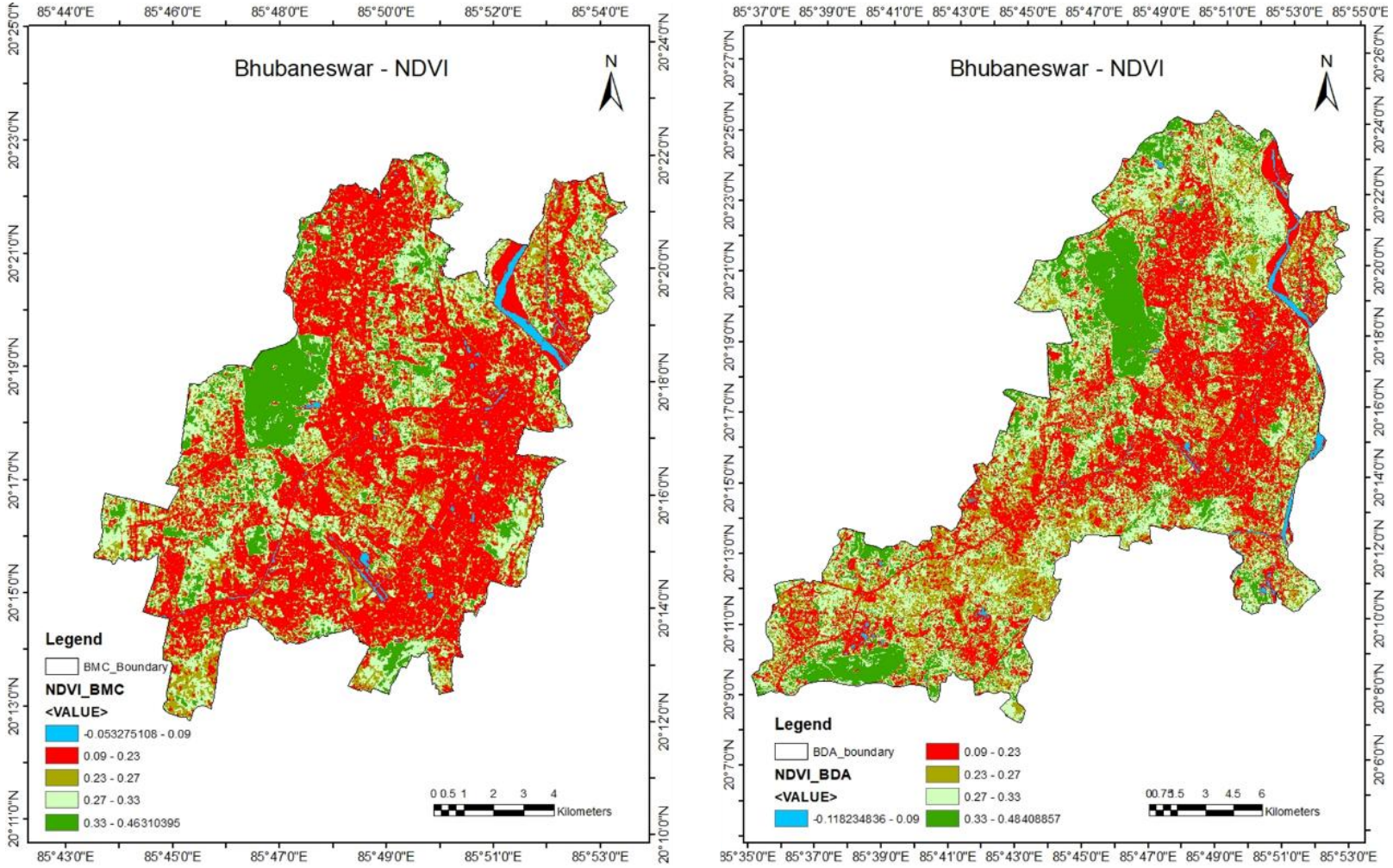
Map 17 Stream and catchment area map and its Euclidean distance map- BDA

B. Indicator: Hydrology (Drainage density and Ground water level)



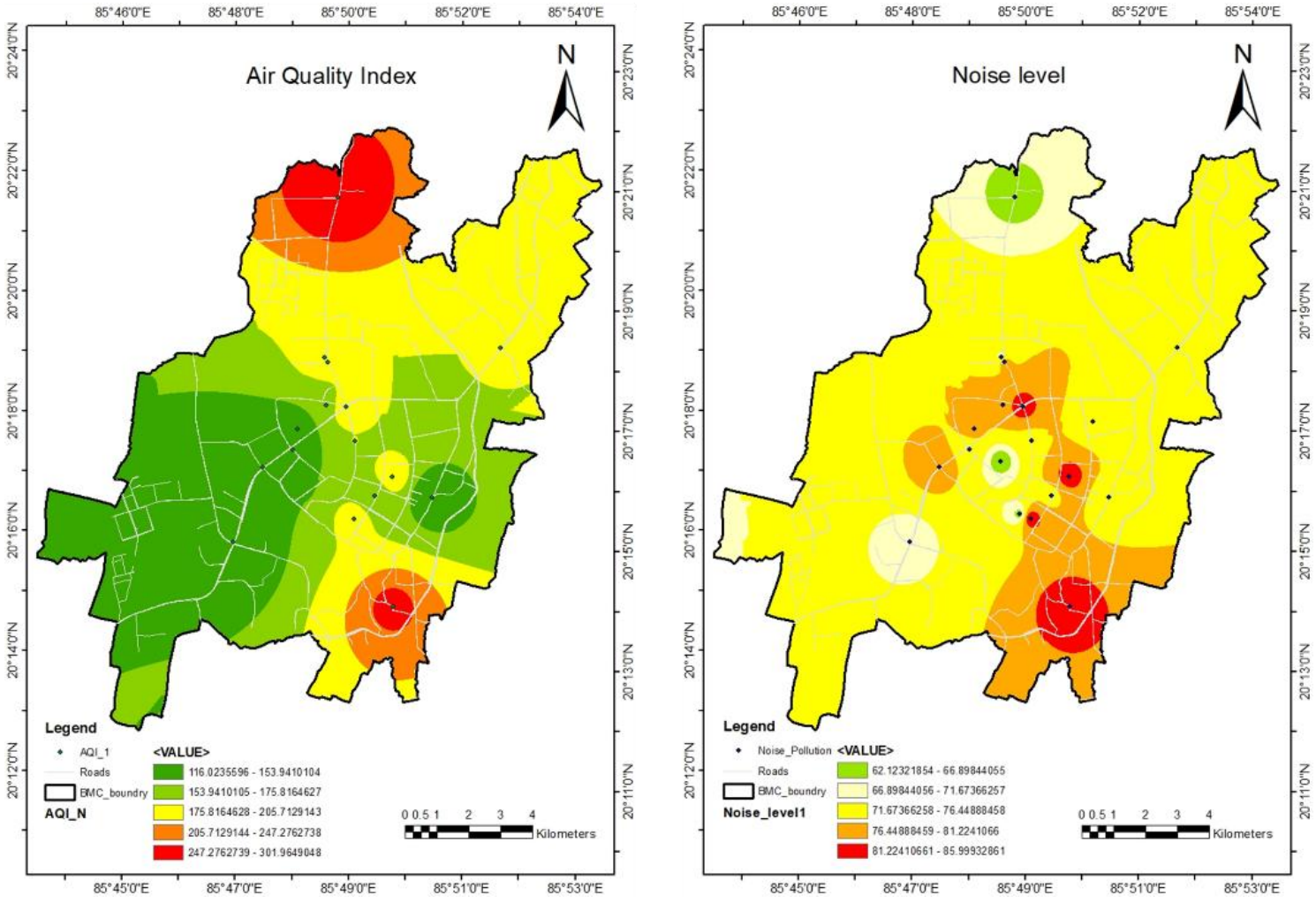
Map 18 Drainage density map; Ground water level Map;

C. Indicator: Natural Vegetation – (NDVI)



Map 19 NDVI map

D. Indicator: Air Quality Index (AQI) and Noise Level

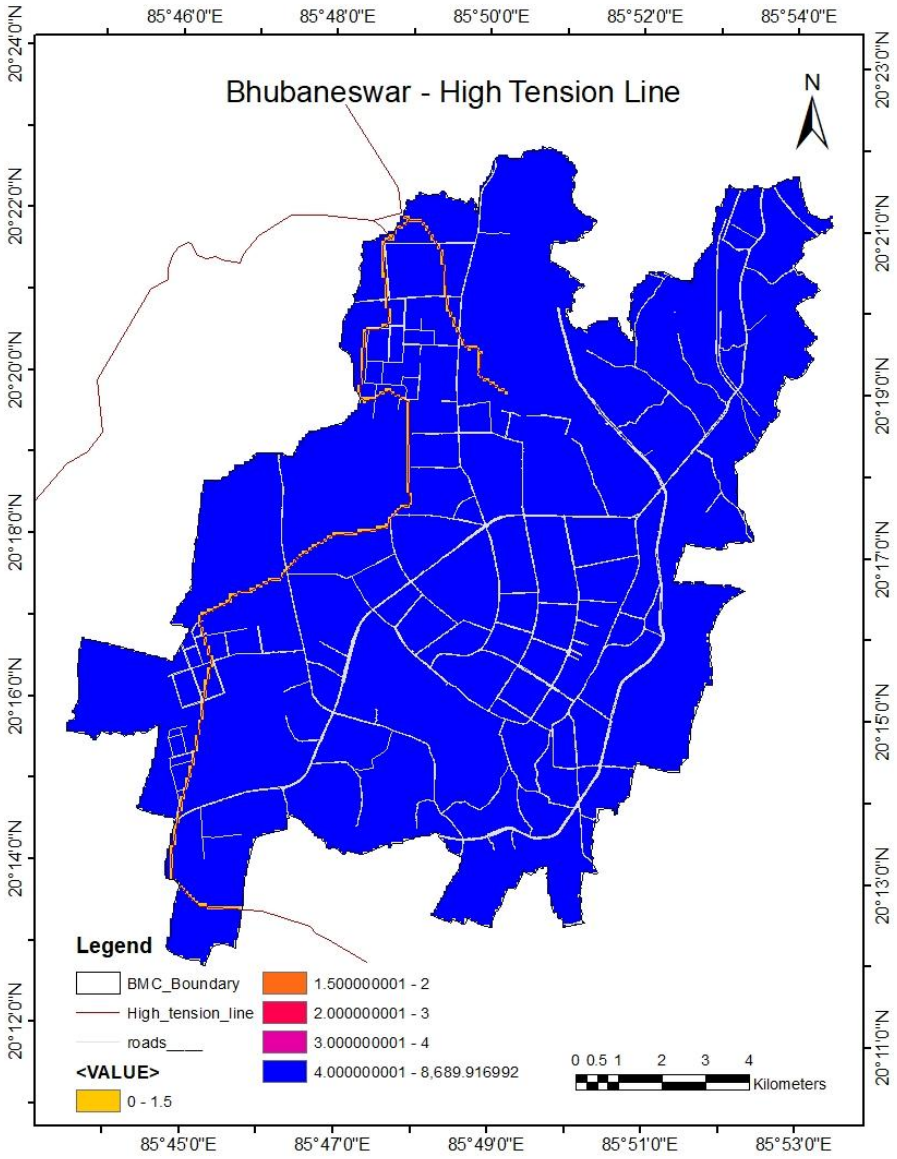


Map 20 Air Quality Index map; Noise level map;

4.2.4 Prohibitive Factors

The theme focuses on analysing cities based on prohibitive factors such as earthquake risk, flooding, and other hazards like mining sites and high-tension power lines. For Bhubaneswar, high-tension power lines (map 21) are considered a key prohibitive factor since the city is not prone to earthquakes or flooding. In contrast, this approach is more critical for coastal or hilly cities where natural hazards are more prevalent. High-tension lines are classified as an exposure hazard because development is restricted in areas beneath or near these lines due to safety regulations and risks associated with such infrastructure.

A. Indicator: Exposure to other hazards- High tension line

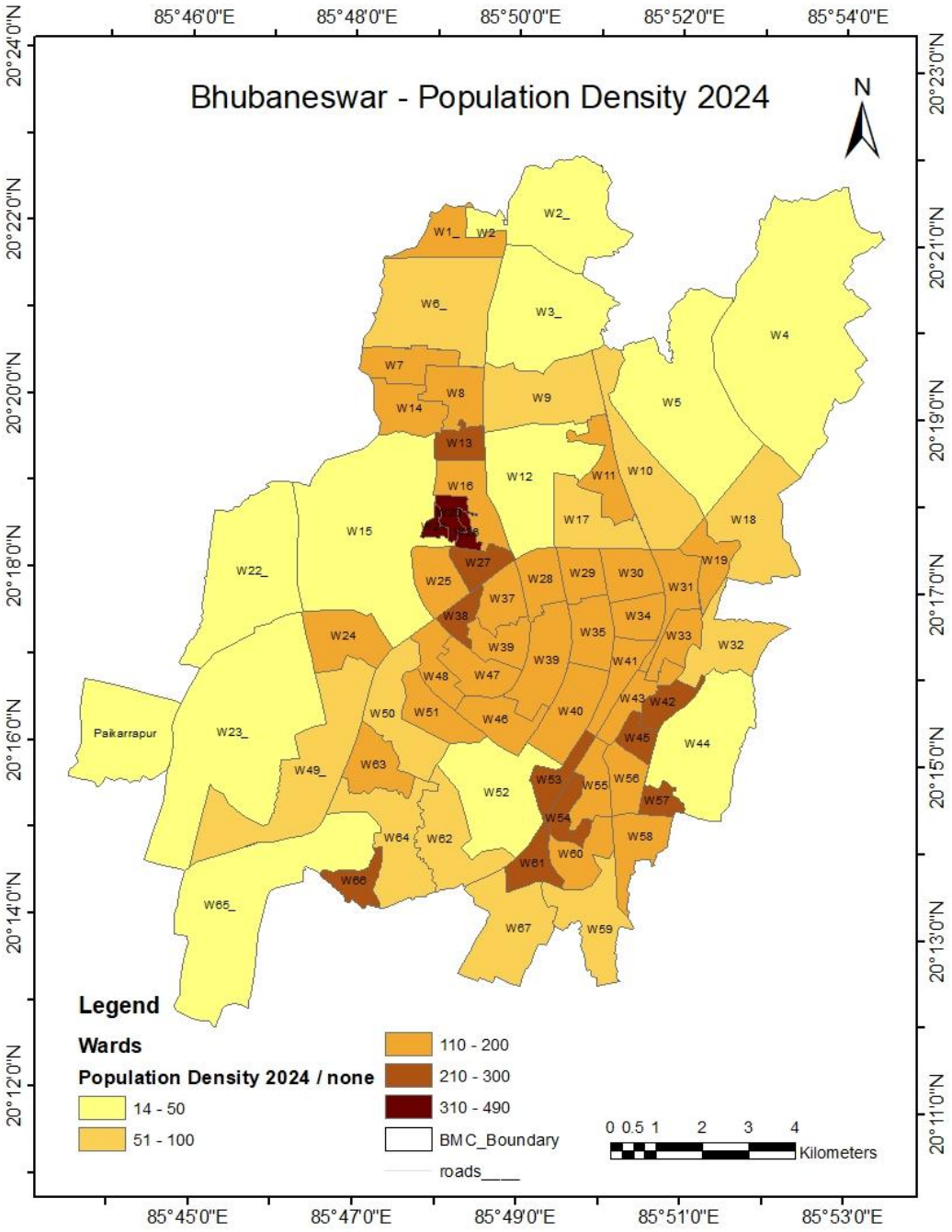


Map 21 High Tension Line-Euclidean Distance

4.2.5 Social Attributes

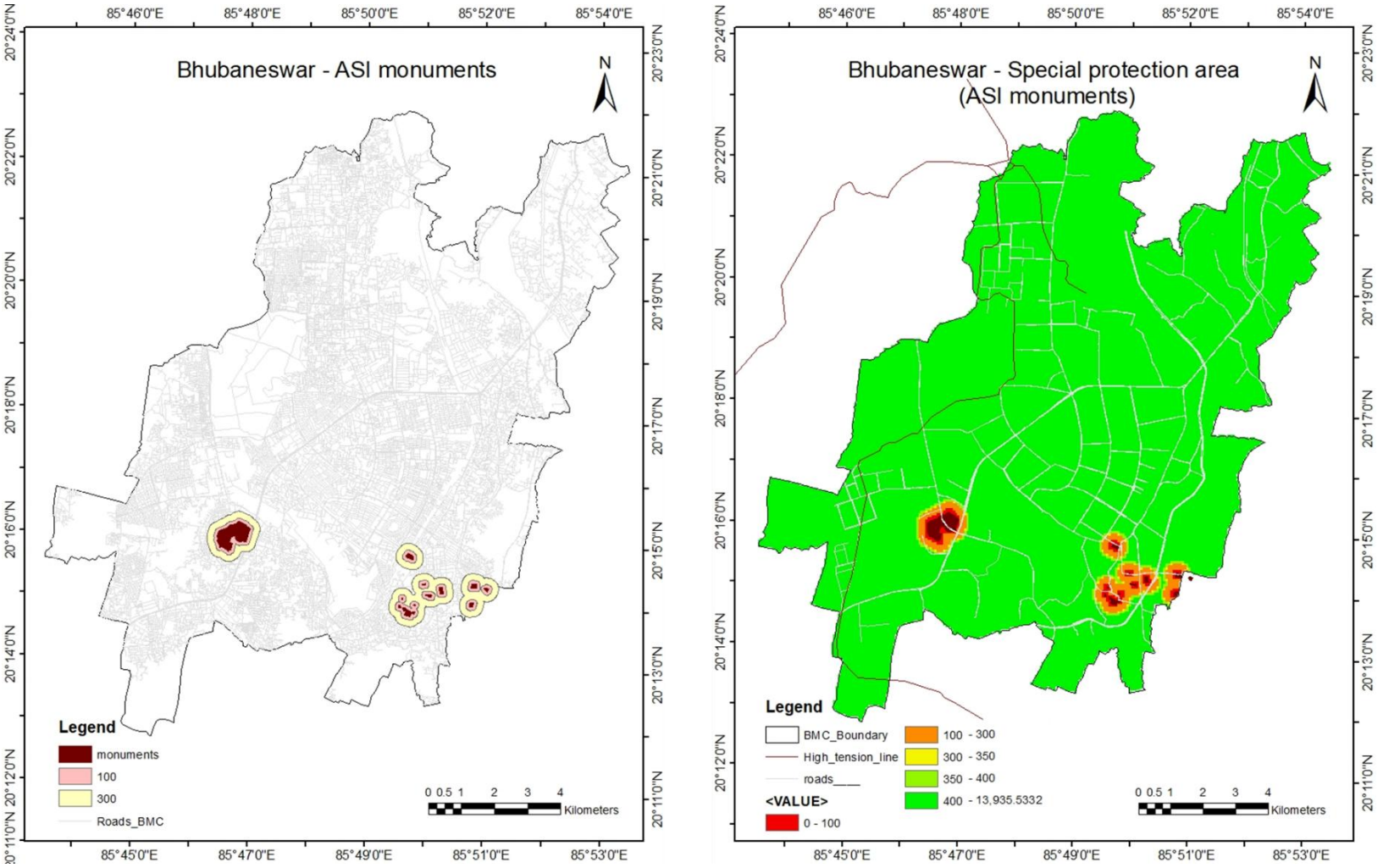
The theme encompasses social aspects that should be incorporated and considered during planning to ensure that residents' perspectives are included in the decision-making process. These aspects typically include factors such as neighbourhood safety, population density, heritage zones, and employment density. However, due to study limitations, only population density (map 22) and heritage lands (map 23) have been taken into account.

A. Indicator: Population Density



Map 22 Population Density 2024

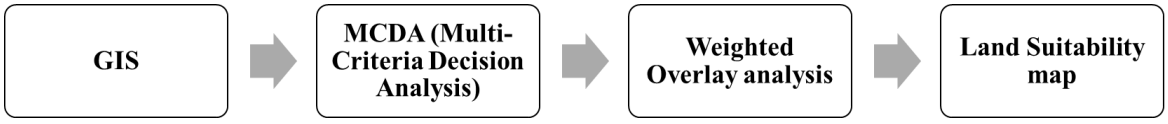
B. Indicator: Special protection area (Heritage lands)



Map 23 Special protection area (Heritage lands)- ASI monuments;

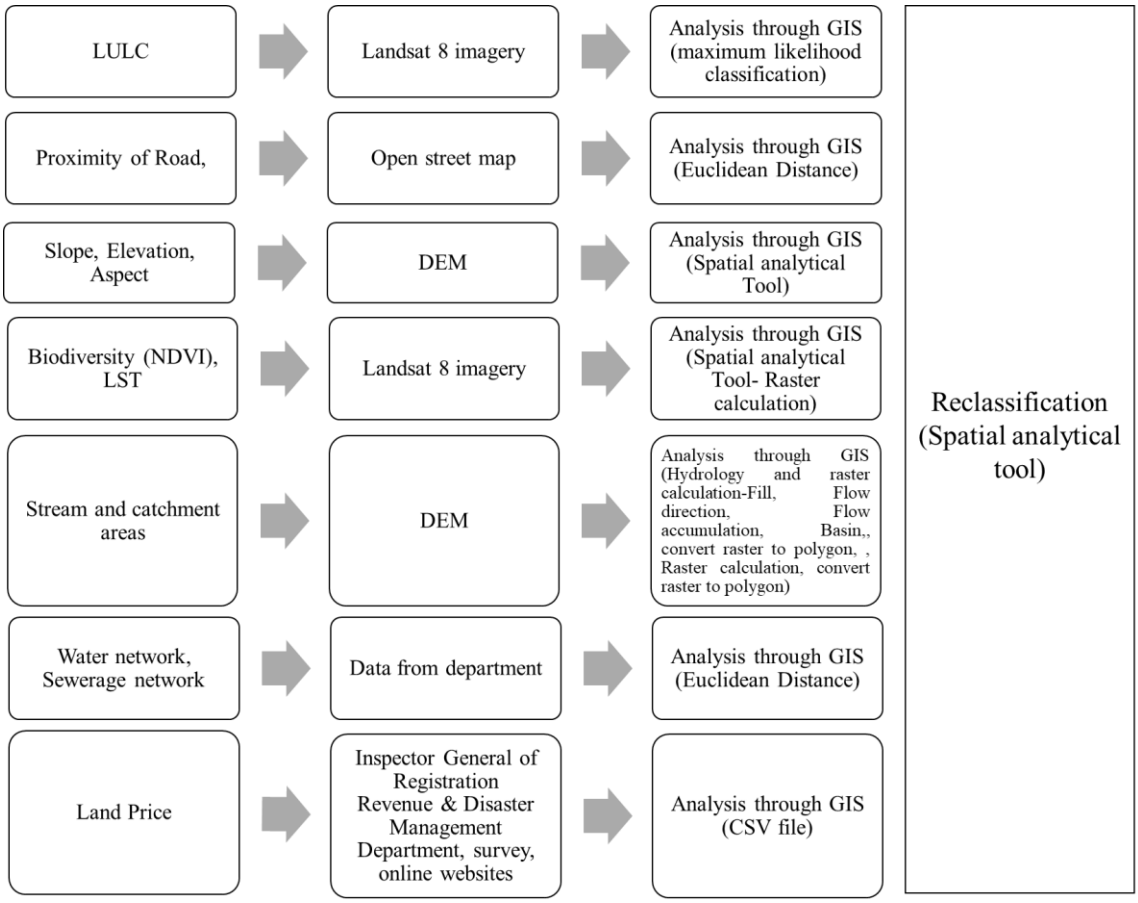
4.3 Land Suitability analysis

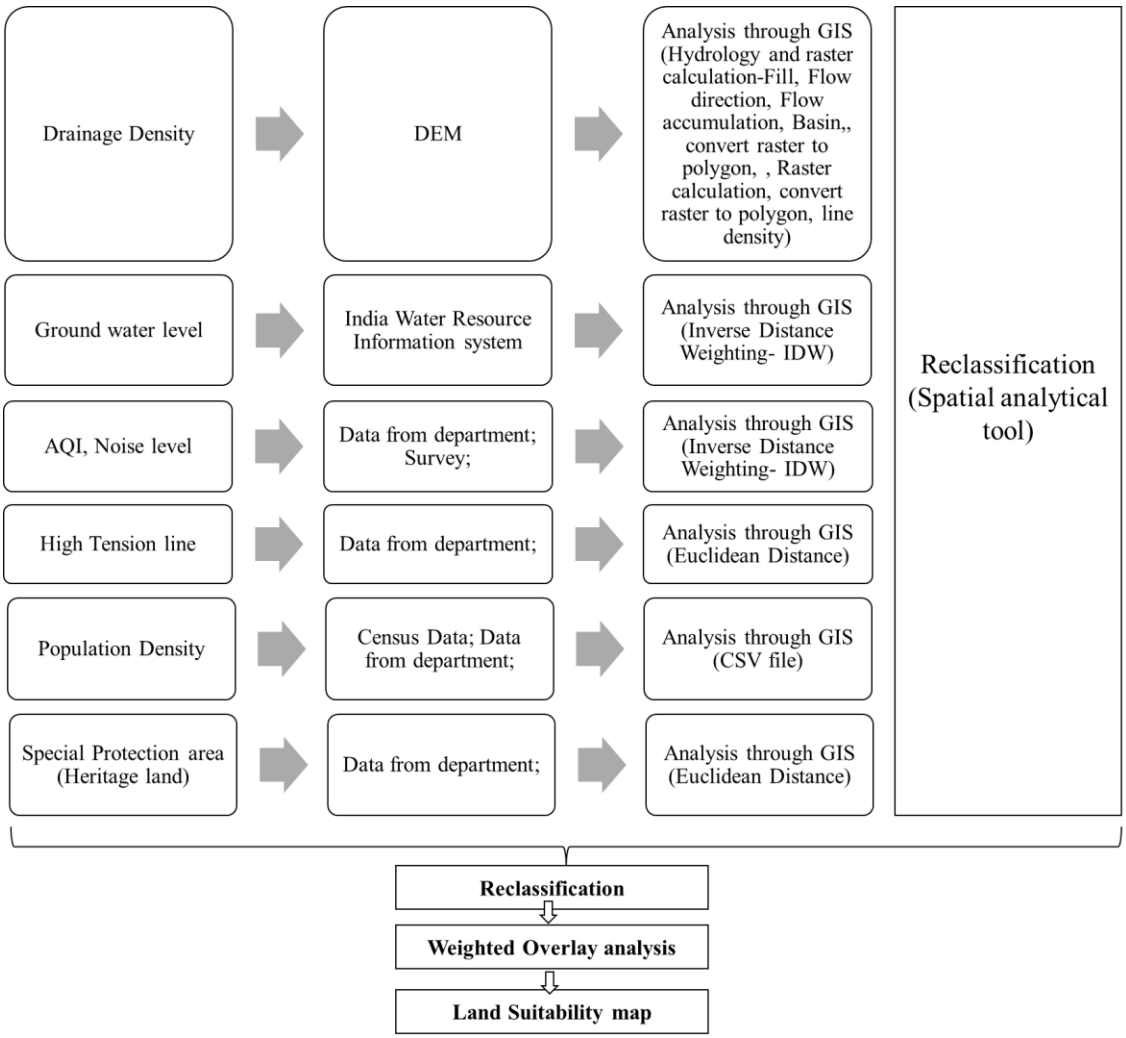
After preparing all the indicator maps, each one is reclassified into five classes using the Reclassify tool in GIS. Following this, a weighted overlay analysis is carried out within the Multi-Criteria Decision Analysis (MCDA), where each indicator is assigned, a weight based on its importance, to produce the final land suitability map.



4.3.1 Weighted Overlay Analysis

The flow diagram illustrates each indicator, its data source, the analysis process, reclassification, and the generation of a suitability map after conducting a weighted overlay analysis.


LULC
Landsat 8 imagery
Analysis through GIS (maximum likelihood classification)
Proximity of Road,
Open street map
Analysis through GIS (Euclidean Distance)
Slope, Elevation, Aspect
DEM
Analysis through GIS (Spatial analytical Tool)
Biodiversity (NDVI), LST
Landsat 8 imagery
Analysis through GIS (Spatial analytical Tool- Raster calculation)
Stream and catchment areas
DEM
Analysis through GIS (Hydrology and raster calculation-Fill, Flow direction, Flow accumulation, Basin,, convert raster to polygon, , Raster calculation, convert raster to polygon)
Water network, Sewerage network
Data from department
Analysis through GIS (Euclidean Distance)
Land Price
Inspector General of Registration Revenue & Disaster Management Department, survey, online websites
Analysis through GIS (CSV file)
Reclassification (Spatial analytical tool)


Drainage Density
DEM
Analysis through GIS (Hydrology and raster calculation-Fill, Flow direction, Flow accumulation, Basin,, convert raster to polygon, , Raster calculation, convert raster to polygon, line density)
Ground water level
India Water Resource Information system
Analysis through GIS (Inverse Distance Weighting- IDW)
AQI, Noise level
Data from department; Survey;
Analysis through GIS (Inverse Distance Weighting- IDW)
High Tension line
Data from department;
Analysis through GIS (Euclidean Distance)
Population Density
Census Data; Data from department;
Analysis through GIS (CSV file)
Special Protection area (Heritage land)
Data from department;
Analysis through GIS (Euclidean Distance)
Reclassification (Spatial analytical tool)
Reclassification
Weighted Overlay analysis
Land Suitability map

As discussed, during the reclassification process, each indicator is assigned a value that reflects its suitability for development. The ranking system is as follows: a value of 1 indicates that the area is not suitable for development, 2 signifies it is less suitable, 3 denotes moderate suitability, 4 indicates suitability, and 5 represents a high suitability for development. Accordingly, these values are assigned to each indicator during the reclassification (refer to Table 11).

After reclassification, weightage has to be provided for each indicator in the weighted overlay analysis. To achieve this, expert opinion surveys were conducted across different departments, including the Bhubaneswar Municipal Corporation, Bhubaneswar Development Authority, State Pollution Control Board of Odisha, and the CRUT Transportation Department in Bhubaneswar. A total of 20 experts were asked to rank the indicators on a scale of 1 to 20 (1 representing the highest importance and with increasing

number the importance decreases, 20 representing the least important indicator), according to their importance when conducting the city's suitability analysis for urban development.

Based on the survey results, the indicators were ranked (see Table 11), and the corresponding weightages were assigned for the weighted overlay analysis.

Table 11 Indicators with values and rating of Indicators as per Expert opinion survey

Themes	Indicator	Interval	Value	Expect opinion	Themes	Indicator	Interval	Value	Expect opinion
Natural Asset	Aspect	0-58.79	5	6	**Ecological and environmental factors**	NDVI	(-0.05_0.09)	1	9
		58.79-138.58	4				0.09-0.23	1	
		138.58-212.76	3				0.23-0.27	5	
		212.76-282.75	2				0.27-0.33	3	
		282.75-356.94	1				0.33-0.46	1	
	Elevation	-35	5	2		Stream	0-100	1	14
		27-39	4				100-200	2	
		39-51	3				200-500	3	
		51-65	2				500-1000	4	
		65-111	1				>1000	5	
	Slope	0-1.25	1	4		Drainage density	0-103.5	1	8
		1.25-3.00	4				103.5-189.5	3	
		3.00-5.00	5				189.5-273.04	4	
		5.00-10.0	3				273.05-367.72	4	
		>10.0	2				367.73-561.49	5	
	LST	67.74-69.34	1	5		Ground water level	0-200	5	7
		69.34-70.47	3				201-400	4	
		70-47-71.37	4				401-600	3	
		71.37-72.74	2				601-800	2	
		72.74-76.24	1				801-1010	1	
	LULC	Waterbody (0)	1	1		Noise Pollution	62-67	5	16
		Green (1)	2				67.01-72	4	
		Built-up (2)	1				72.1-76.5	3	
		Agriculture land (3)	3				76.6-81.2	2	
		Barren land (4)	5				81.3-86	1	

Strategic Planning	Road proximity	0-250	5	3		AQI	0-154	5	15
		250-500	4				155-175	4	
		500-750	3				175-205	3	
		750-1000	2				206-247	2	
		>1000	1				248-302	1	
	Water Network	0-100	5	10	**Prohibitive factors**	High tension line	0-1.5	1	12
		101-150	4				1.51-2	2	
		151-250	3				2.01-3	3	
		251-300	2				3.1-4	4	
		>300	1				>4	5	
	Sewerage Network	0-100	5	13	**Social Attributes**	Population Density	14-50	5	11
		101-150	4				50-100	4	
		151-250	3				100-150	3	
		251-300	2				200-300	2	
		>300	1				300-494	1	
	Land Price	3500-4000	5	18		Special protection area (Heritage lands)	0-100	1	17
		4001-6000	4				101-300	2	
		6001-8000	3				301-350	3	
		8001-10000	3				351-400	4	
		10001-12500	3				>400	5	

Note: In rating, as per Expert opinion survey, 1 holds the highest importance and as the count increases the importance of the indicator decreases.

4.3.2 Scenario generation

To assess the suitability of land in the city, three scenarios were developed based on the importance assigned to various indicators by experts in a survey. In the first scenario, indicators related to Natural Assets, Strategic Planning, and Ecological and Environmental Factors (as detailed in Table 12) were prioritized as the most important for the land suitability analysis. The second scenario focused on indicators associated with Prohibitive Factors, reflecting their significance according to expert opinion. Finally, the third scenario incorporated indicators from the social theme, which were deemed to have lower priority. Each scenario was analysed independently, allowing us to evaluate how the inclusion of indicators from each theme affected the overall results of the land suitability analysis.

Table 12 Scenarios 1,2, and 3 with its weightage given in Weighted Overlay analysis respectively.

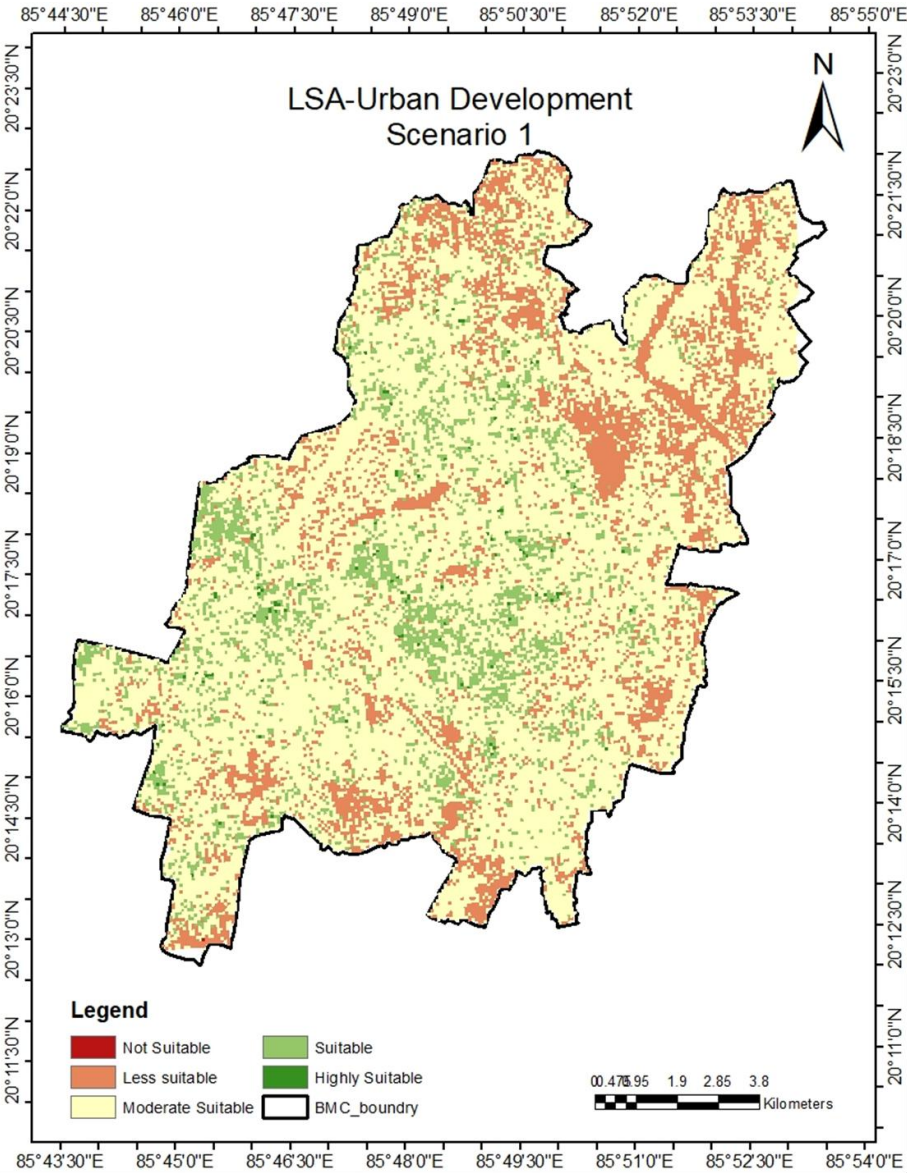
Themes	Scenario 1	Scenario 2	Scenario 3
Natural Asset	50	45	30
Strategic Planning	30	30	25
Ecological and environmental factors	20	20	20
Prohibitive factors	Not Included	5	5
Social Attributes (Population Density)	Not Included	Not Included	15
Social Attributes (ASI monuments)	Not Included	Not Included	5

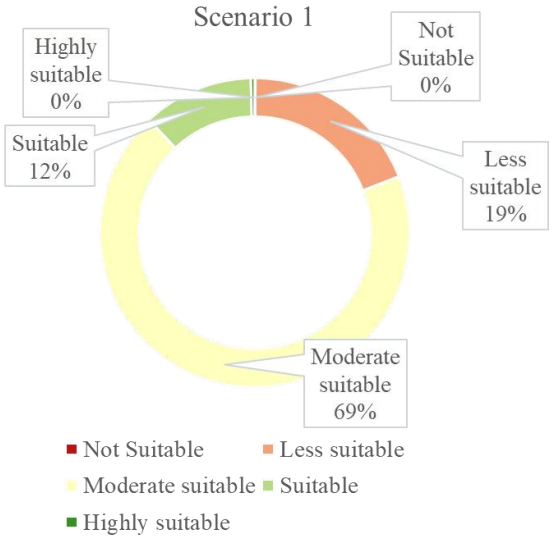
A. Scenario 1

In scenario 1 (map 24), the process of generation of Land Suitability maps involves, selection of indicators, grouped under three primary themes, i.e., Natural Asset, Strategic Planning, and Ecological and environmental factors. These themes were chosen for the first scenario, because they incorporate the most influential factors affecting land suitability, identified through expert opinion surveys.

B. Scenario 2

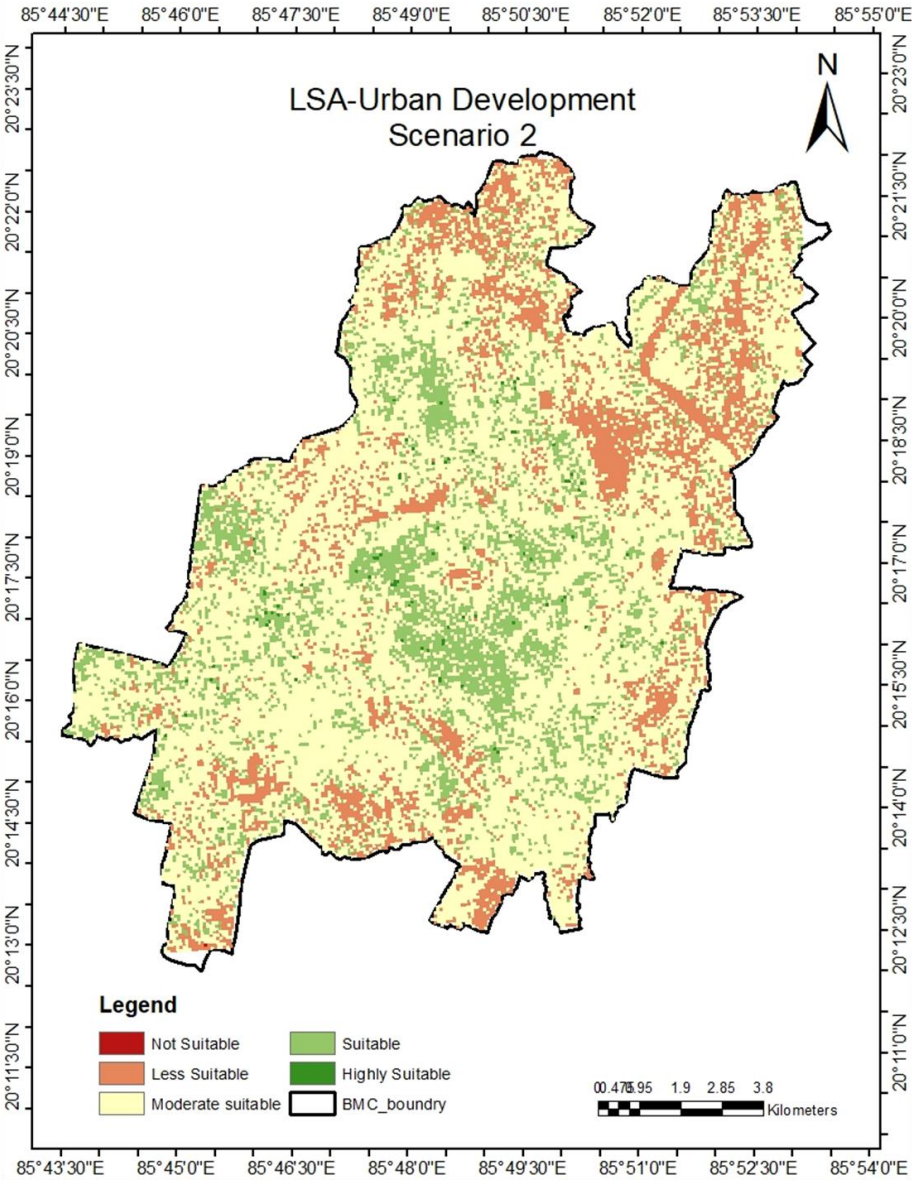
Unlike scenario 1, in scenario 2 (map 25), a land suitability map was generated using indicators from four themes. This approach allows broader analysis, providing insights into how increasing the number of indicators can influence the results and highlights the effect of each indicator on Land suitability results, and emphasizes the importance of selecting indicators that align with the study's objectives. For urban development, it is essential to consider all relevant indicators, as each plays an important role in site selection. For example, in the case of Bhubaneswar, while prohibitive factors like high tension lines are significant, whereas earthquake and flood risks are minimal due to its plain geography, these other prohibitive theme-indicators would be more critical in hilly or coastal cities. Therefore, the choice and weighting of indicators should be made accordingly, reflecting local conditions and the specific goals of the urban suitability assessment.

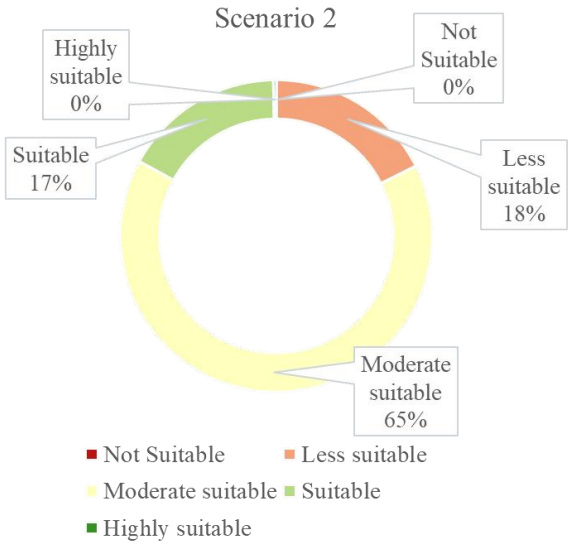




Class	Area (Sq.km.)
Not Suitable	0.06
Less suitable	19.03
Moderate suitable	68.93
Suitable	11.58
Highly suitable	0.40

Map 24 Land Suitability Map of Scenario-1.



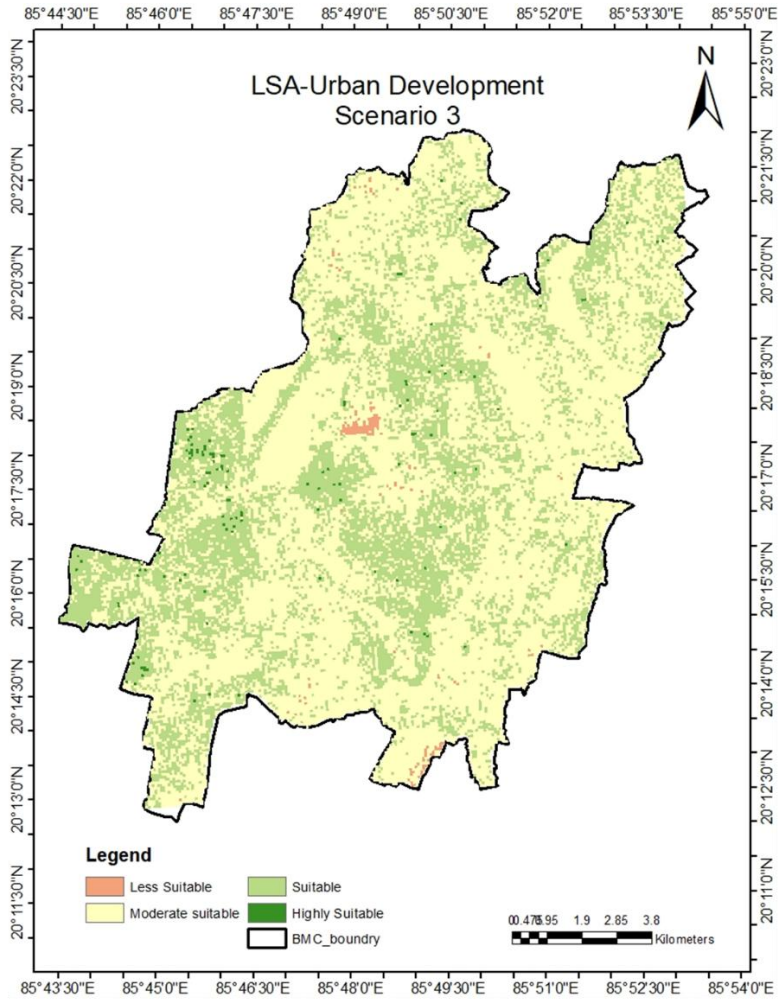


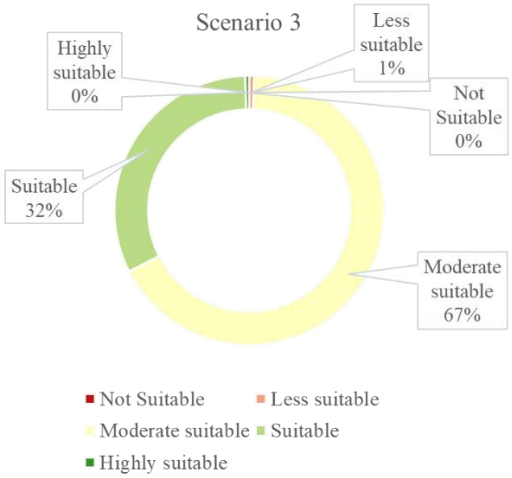
Class	Area (Sq.km.)
Not Suitable	0.04
Less suitable	17.56
Moderate suitable	65.34
Suitable	16.75
Highly suitable	0.31

Map 25 Land Suitability Map of Scenario-2.

C. Scenario 3

A land suitability map in scenario 3 (map 26) is generated, including all five themes and 18 indicators distributed among themes. This approach ensures a comprehensive assessment of land suitability.





Class	Area (Sq.km.)
Not Suitable	0.00
Less suitable	0.60
Moderate suitable	66.92
Suitable	32.01
Highly suitable	0.47

Map 26 Land Suitability Map of Scenario-3.

Analysis for urban development and land optimization each theme is important, and their own set of indicators, captures a wide range of environmental, physical, and socio-economic factors that influence the suitability of land for the intended purpose. The inclusion of 18 indicators enabled a more comprehensive and thorough analysis, helping to identify the most appropriate land parcels by considering all the relevant indicators that could impact urban development. This enhances the accuracy of land suitability analysis map and also provides valuable insights for decision-makers such as urban planners, and policymakers.

D. Comparative analysis of all Scenarios

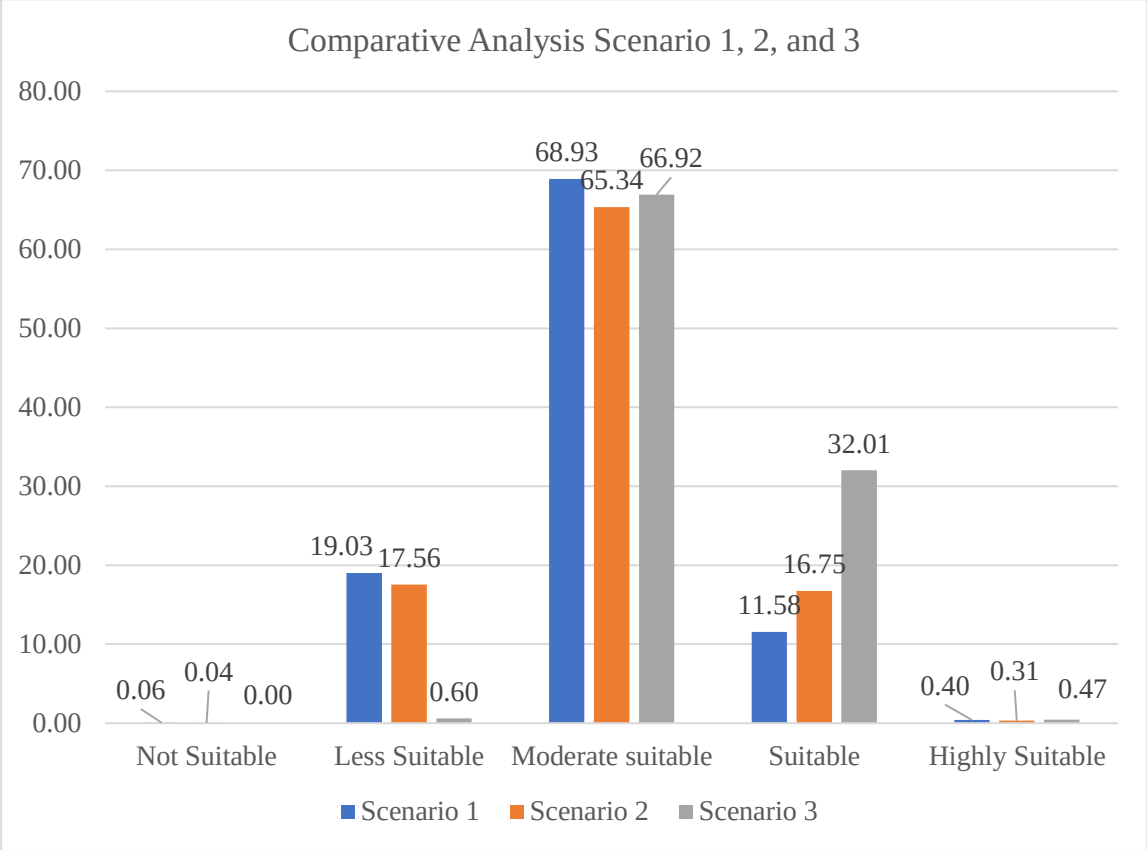


Figure 15 Comparison of percentage of land under each category

Table 13 Percentage of Land-under each category

Description	Scenario 1	Scenario 2	Scenario 3
Not Suitable	0.06	0.04	0.00
Less Suitable	19.03	17.56	0.60
Moderate suitable	68.93	65.34	66.92
Suitable	11.58	16.75	32.01
Highly Suitable	0.40	0.31	0.47

Analysis:

A comparison of the three scenarios illustrates how methodological decisions in indicator selection greatly impact the overall outcome of land suitability analysis. Each scenario's individual set of themes and indicators influences the way land is categorized, and changes the pattern of land suitability categories, finally determining the interpretation of suitable land for development.

In the initial two scenarios, land is assigned to five categories of suitability (e.g., highly suitable, moderately suitable, etc.) (fig. 15, table 13), implying a wider land categorization on the basis of indicators applied. In Scenario 3, where extra indicators like population density and Special Protection Areas (heritage areas) have been added, the pattern totally shifts. The majority of the land is in the "developable" category, with only 1% being "less suitable." In addition, the land is divided into four suitability classes rather than five, suggesting a consolidation of categories due to the new indicators added.

The addition of the population density indicator stands out in Scenario 3. Because most wards in the city are of low population density, this indicator leads to nearly the whole urban area being found suitable for development. This highlights how the addition of certain indicators can have a dramatic effect on land suitability outcomes, potentially giving preference to certain development priorities over others.

4.4 Carrying capacity

Carrying capacity is the maximum population that a given area can sustain. Urban carrying capacity serves as a tool to determine the highest number of people an urban area can accommodate while maintaining sustainability. It represents a threshold beyond which the environment may degrade due to the strain of population growth, prompting natural systems to restore balance. Urban carrying capacity considers factors such as infrastructure, resource availability, and environmental impact to evaluate sustainability and manage urban development [46].

Formula: $CC = AU - (AND + AIF) \times FAR/S$ 2

AU = Total delineated urban area	AIF = Area under infrastructure development
	FAR = Floor area ratio

AND = Non developable land = Total urban area - (developed area + area for infrastructure)	S = Floor area requirement per head

4.4.1 Carrying capacity of 2011

The 2011 carrying capacity was examined as a first step before examining the carrying capacity of 2025 (fig 16, table 14,15). This was useful in learning about how the city had previously been able to sustain its population and hence inferred useful information regarding trends and developments, for example, availability of resources, and the effect of urban growth over time. This historical context is crucial for properly assessing how the carrying capacity of the city could change and for informing decision-making on sustainable urban planning for 2025 and the future.

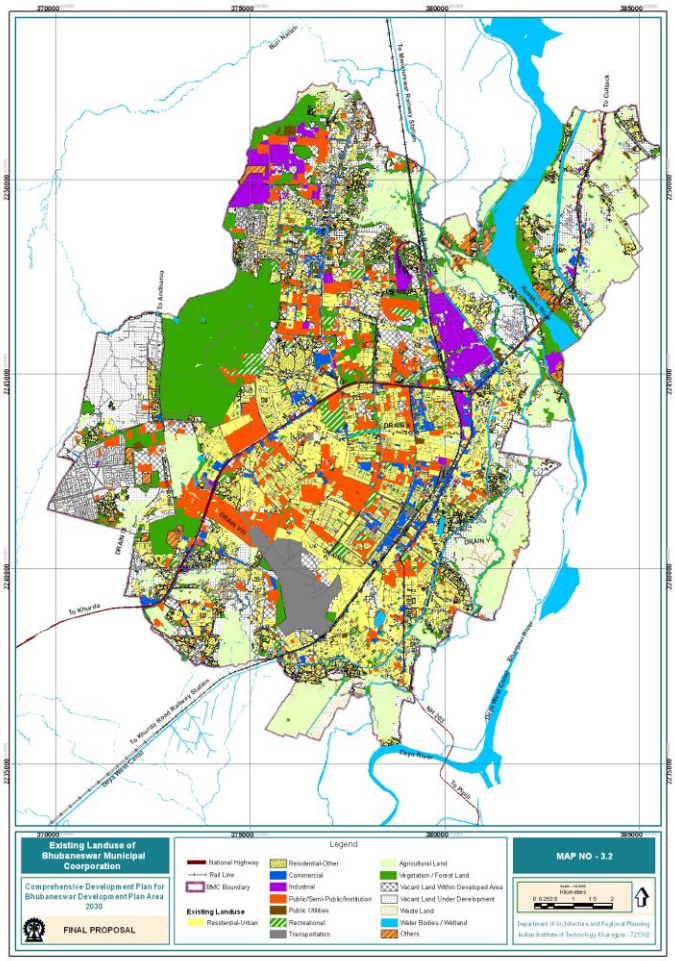


Figure 16 Land-use map 2010

Source: CDP for BDPA-2030; The effect of social and spatial processes on the provision of Urban open spaces: the case of Bhubaneswar in India

Table 14 Land use 2010

Land uses	Area (Sq.km.)	Percentage (%)	Land uses	Area (Sq.km.)	Percentage (%)
Residential	31.901	21.85	Waterbody	3.6792	2.52
Commercial	2.4966	1.71	Vacant land	33.288	22.8
PSP	10.8916	7.46	waste land	6.3364	4.34
Utilities and services	0.7884	0.54	Agriculture	18.177	12.45
Industrial	3.504	2.4	Protected forest and reserve Forest	16.936	11.6
Recreational	2.7156	1.86	Others	2.4382	1.67
Transportation	12.848	8.8			

For calculating the carrying capacity of Bhubaneswar city in 2011, the SAFE (Sustainable Accommodation through Feedback Evaluation) model was used.

Table 15 Carrying capacity 2010

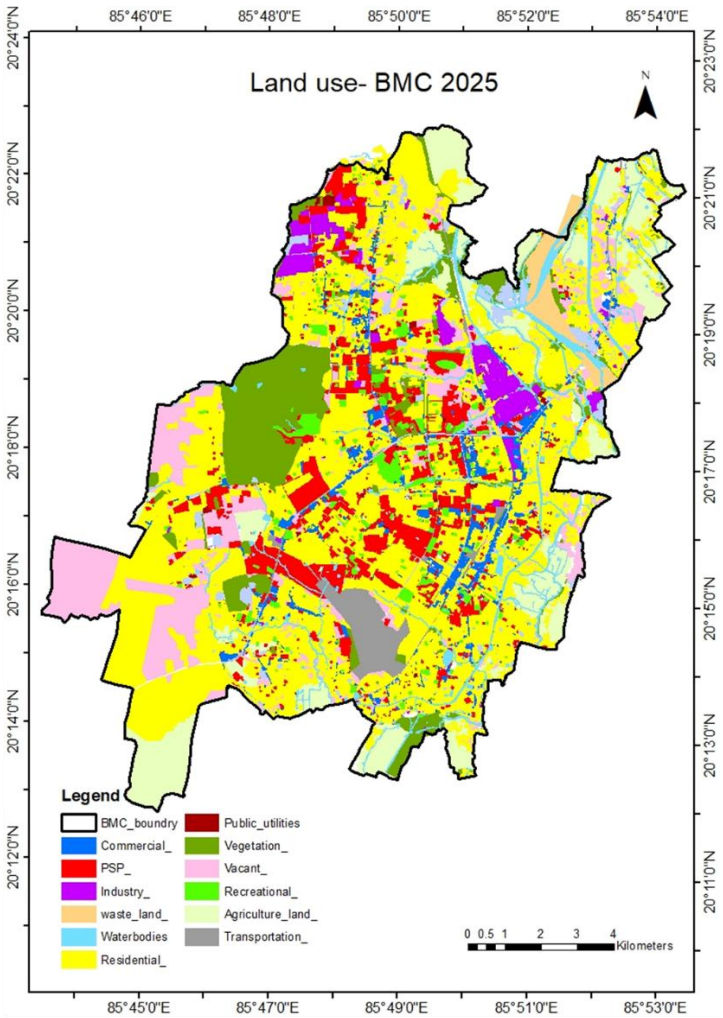
Terms	Description	Area (sq.km.)	Area in (Ha.)	Terms	Description	Area (sq.km.)	Area in (Ha.)
AU	**Total Urban land (AD+AND)**	**146**	**14600**	**AIF**	**Area under infrastructure**	**66.5322**	**6653.22**
AND	**Non-Developable land**	**47.5668**	**4756.68**		Commercial	2.4966	249.66
AD	**Developable area (AR+AIF)**	**98.4332**	**9843.32**		Industrial	3.504	350.4
AR	**Area for residential requirements**	31.901	3190.1		Public Semi public	10.8916	1089.16
FAR	**Floor area Ratio**	**2**			Recreational	2.7156	271.56
S	**Floor area requirement per Head**	**0.0000702**	**0.007**		Transportation	12.848	1284.8
	60% of developable area (AD)/ total area				Utility and services	0.7884	78.84
					Vacant land	33.288	3328.8

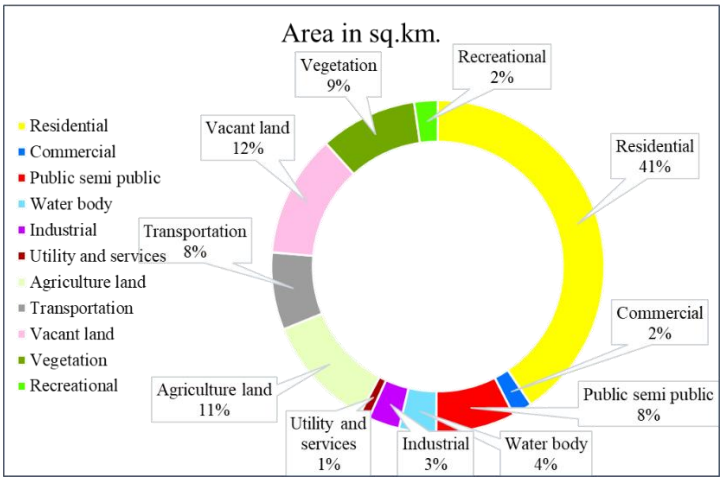
For calculating the carrying capacity of Bhubaneswar city in 2011, the population considered was 840,834, and the Floor Area Ratio (FAR) was taken as 2. Equation 2 ($CC = AU - (AND + AIF) \times FAR/S$) was used for calculating the carrying capacity.

After the calculation, it was found that the city's carrying capacity was higher than its actual population, with a carrying capacity of 911,443 people.

4.4.2 Carrying Capacity 2025

Since the carrying capacity analysis for 2011 indicated that the city could support its population at that time, the carrying capacity for 2025 has also been evaluated to analyse the city's ability to accommodate its current population (map 27, table 16,17).





Map 27 Land-use 2025

Table 16 Land-use 2025

Land use- 2025					
Description	**Area in sq.km.**	**Acres**	**Percentage**	**URDPFI 2014**	**Remark**
Residential	75.44	18641.6	41	36-38	Sufficient
Commercial	3.57	882.2	2	5-6	Shortage
Public semi public	14.29	3531.1	8	10-12	Shortage
Water body	6.69	1653.1	4		
Industrial	5.65	1396.1	3	7-8	Shortage
Utility and services	1.76	434.9	1		
Agriculture land	20.65	5102.7	11		
Transportation	13.99	3457.0	8	12-14	Shortage
Vacant land	22.16	5475.9	12		
Vegetation	17.56	4339.2	9		
Recreational	4.24	1047.7	2	14-16	Shortage
Total	185.97	45961.6	100		

The land-use distribution indicates that the majority of land in the city is designated for residential purposes (41%). This is followed by vacant land (12%) and agricultural land (11%). In contrast, only 2% of the land is allocated for commercial use, while just 8% is dedicated to public, semi-public, and transportation purposes (map 27, table 17).

Table 17 Carrying Capacity-2025

Terms	**Description**	**Area (sq.km.)**	**Area in (Ha.)**
AU	**Total Urban land (AD+AND)**	**185.98**	18598.370
AND	**Non-Developable land**	**45.54**	4553.757
	Protected areas	7.89	789.000
	Special areas	37.65	3764.757
AD	**Developable area (AR+AIF)**	**140.45**	14044.612
AR	Area for residential requirements	75.44	7543.970
AIF	Area under infrastructure	65.01	6500.643
	Commercial	3.57	356.727
	Industrial	5.65	564.933
	Public Semi public	13.65	1365.000
	Recreational	4.24	423.986

	Transportation	13.99	1398.870
	Utility and services	1.76	175.581
	Vacant land	22.16	2215.546
FAR	**Floor area Ratio**	**2**	
S	**Floor area requirement per Head**	**0.00007**	**0.007**
	60% of developable area/ total area		

To better analyse the existing situation while calculating the city's carrying capacity, two different calculations were performed: one considering a Floor Area Ratio (FAR) of 1.5, and the other considering a FAR of 2.

For calculating the carrying capacity (equation 2), the 2024 population of 14,63,190 was considered, with a FAR of 1.5. The results indicate, similar to the 2011 analysis, that the city can sustain its population in both 2024 and 2025, with a calculated carrying capacity of 16,14,808 people.

With a 2024 population of 14,63,190 and a Floor Area Ratio (FAR) of 2, the estimated carrying capacity is 21,53,102 people.

However, when the FAR is increased to 2, the results show that the city can sustain the projected population for 2031, which is 19,71,740. However, it will not be able to accommodate the projected population for 2041, which is 30,19,391, which surpasses the current carrying capacity limit.

Overall, this analysis indicates that, for the city to sustain its future population, its carrying capacity will need to be enhanced.

4.4.3 Zone-wise carrying capacity

Following the city's overall carrying capacity analysis to establish its population limit, an extended assessment was made at the zonal level. There are three zones in Bhubaneswar: South-West Zone, South-East Zone, and North Zone. Each of them was separately assessed for carrying capacity to further understand population distribution and sustainability in various regions of the city.

A. South-West Zone- Zone 1

The carrying capacity of the South-West Zone (Zone 1) was examined to see if this zone of the city has the ability to harbour the growing population pressure. The examination can be used in establishing whether the South-West Zone has enough capacity to support population increase in the future in a sustainable manner, taking into account continuous urbanization and infrastructure needs (map 28, table 18,19).

In Zone 1, a sizable percentage of land (41%) is specifically for residential usage, which adheres to the common trend where residential land occupies the largest share in urban areas. Interestingly, from the city's total 12% vacant land, 7% is situated within Zone 1. However, only a small portion of Zone 1 is designated for commercial and utility/service purposes, with just 1% of its area dedicated to these uses. Besides, the area lacks adequate recreational areas since only 2% of its land area is allocated for recreational purposes (map 28, table 18).

The carrying capacity analysis (equation 2) for Zone 1 (table 19) was conducted using the 2024 population of 448,254 and a Floor Area Ratio (FAR) of 1.5. According to the analysis, the carrying capacity of Zone 1 in 2025 is 585,133 people, indicating that the zone is currently capable of accommodating its population.

However, with the projected population for 2031 expected to reach 604,050, which will exceed the carrying capacity of the zone, infrastructure and resource enhancements will be necessary to meet growing demands and ensure the zone can continue to sustain its population in the future.

B. South-East Zone- Zone 2

The carrying capacity analysis for the South-East Zone was performed to evaluate its ability to accommodate the population. This zone-specific analysis allows for a better understanding of the zone's capacity and requirements, facilitating for the development of area-level recommendations and strategies that address the specific demands of the zone (map 28, table 18,19).

The land-use distribution in the South-East Zone shows that residential land use constitutes for the highest percentage (47.7%), followed by agricultural land (12.13%), transportation (8.79%), and public/semi-public uses (7.77%). However, commercial, recreational,

vegetation, and utility and services land uses occupy much smaller proportions of the total area (map 28, table 18).

The carrying capacity of Zone-2 (table 19) (equation 2) is calculated using the 2024 population of 5,35,514 and a FAR of 1.5. Based on this, it is observed that this zone can support up to 787,234 people.

The projected population for 2031 is 721,639, and for 2041 it is 1,105,070. Based on the calculations, Zone 2 can accommodate the population up to 2031, but its carrying capacity will be exceeded by 2041.

C. North Zone -Zone 3

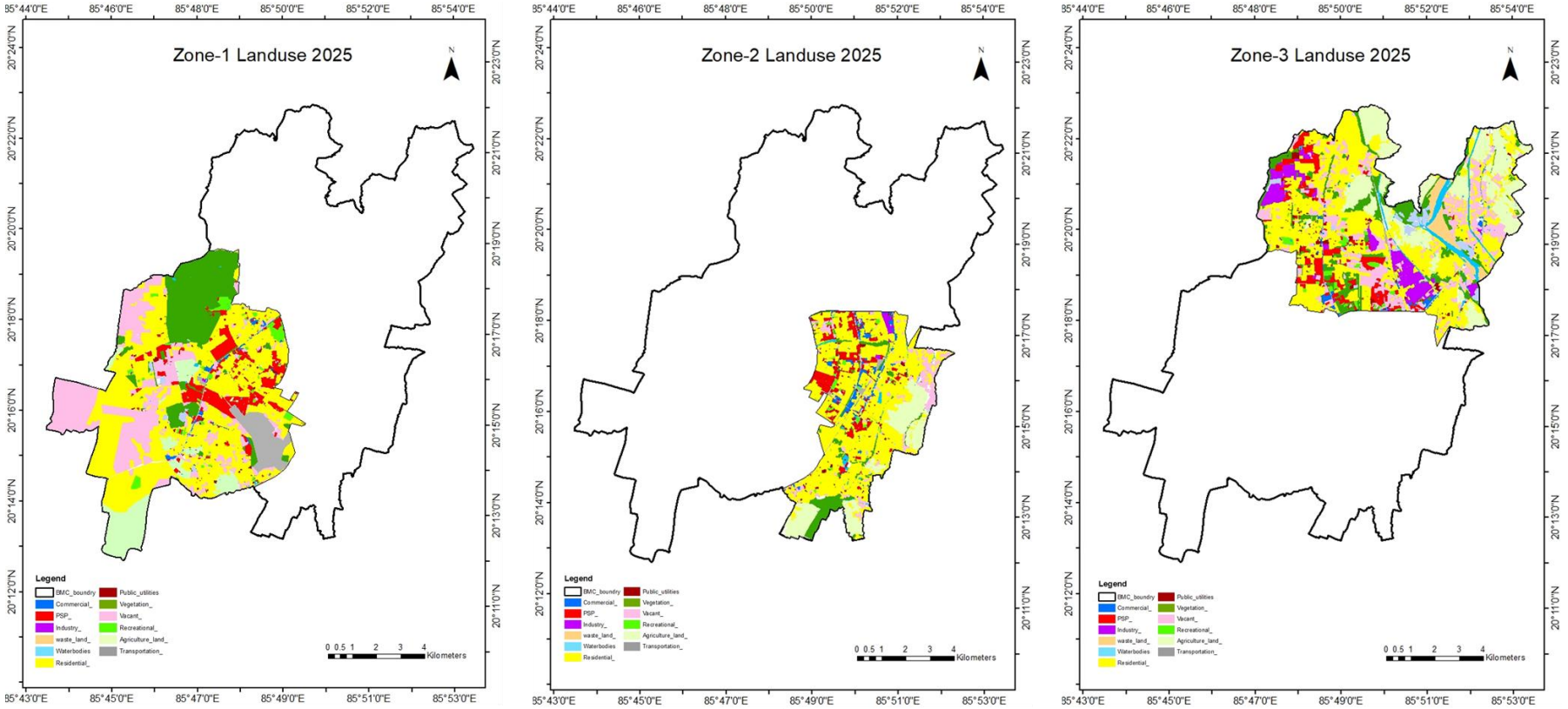
The carrying capacity of the North Zone is analysed to provide in-depth information about this area. This analysis helps determine whether the zone's carrying capacity has been exceeded and requires enhancement, or if it is currently sufficient to meet the population's needs (map 28, table 18,19).

The land-use distribution is presented in Table 18. As shown in the table, residential land use constitutes the largest share at 36.1%. In contrast, utility and services, commercial, and recreational land uses have the smallest shares, accounting for 1.5%, 2%, and 2.3% respectively.

The calculation for carrying capacity for Zone-3 (equation 2) is done using a population of 2024, 4,79,422, and a FAR of 1.5. The carry capacity after calculation is 6,13,357 population.

The carrying capacity for Zone 3 is calculated using the 2024 population of 479,422 and a Floor Area Ratio (FAR) of 1.5. The resulting carrying capacity is 613,357 people.

This verifies that Zone 3 can satisfy the demand of the population in 2025. Nevertheless, as the projected 2031 population stands at 646,051, the zone will be beyond its capacity by then. As such, other resources and infrastructure will need to be extended to cater for future needs and increased population due to urbanization.



a b c

Map 28 Zone-1, 2, 3- Land use

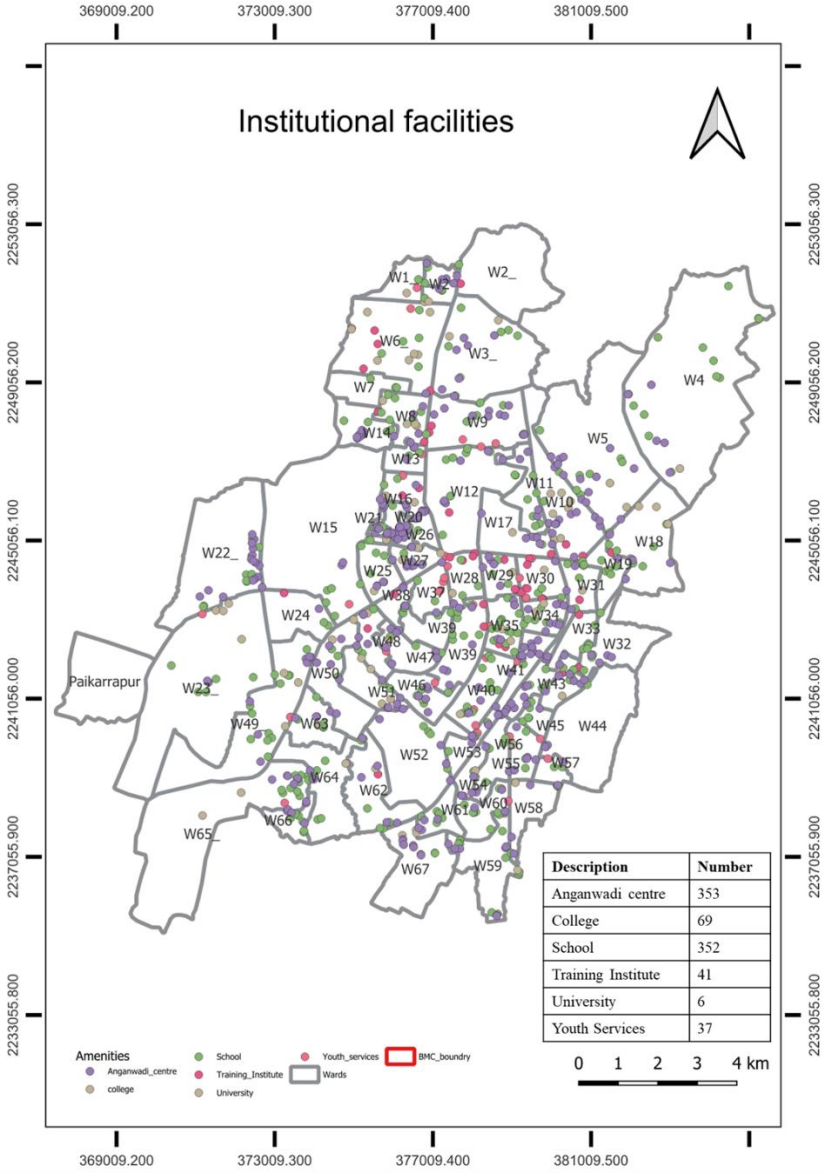
Table 18 Zone-1, 2, 3- Land-use percentage

Description	Zone 1			Zone 2			Zone 3		
	Area in Sq.km.	Percentage	Overall Percentage	Area in Sq.km.	Percentage	Overall Percentage	Area in Sq.km.	Percentage	Overall Percentage
Residential	31.084448	41	16.7	19.09	47.77	10.26	25.2	36.1	13.55
Commercial	0.917378	1	0.5	1.56	3.89	0.84	1.4	2.0	0.75
Public semi public	5.363548	7	2.9	3.10	7.77	1.67	4.7	6.8	2.53
Water body and waste land	0.624277	1	0.3	1.32	3.31	0.71	4.6	6.6	2.47
Industrial	0.311099	0	0.2	0.61	1.54	0.33	4.0	5.7	2.15
Utility and services	0.459274	1	0.2	0.56	1.39	0.30	1.0	1.5	0.54
Agriculture land	5.586915	7	3.0	4.85	12.13	2.61	10.5	15.0	5.65
Transportation	6.689546	9	3.6	3.51	8.79	1.89	4.0	5.8	2.15
Vacant land	12.941395	17	7.0	2.08	5.21	1.12	7.4	10.6	3.98
Vegetation	10.254508	13	5.5	2.15	5.39	1.16	5.4	7.7	2.90
Recreational	1.76563	2	0.9	1.12	2.81	0.60	1.6	2.3	0.86
Total	75.99			39.96			69.9		

Table 19 Carrying capacity-Zone 1, 2, and 3

Terms	Description	Zone -1	Zone-2	Zone-3
		Area (sq.km.)	**Area (sq.km.)**	**Area (sq.km.)**
AU	**Total Urban land (AD+AND)**	**76.00**	**40.23**	**69.94**
AND	**Non-Developable land**	**16.47**	**8.32**	**20.50**
	Protected areas	7.89	0	0
	Special areas	8.58	8.32	20.50
AD	**Developable area**	**59.53**	**31.91**	**49.44**
AD	AR+AIF			
AR	Area for residential requirements	31.08	19.00	25.24
AIF	**Area under infrastructure**	**28.45**	**12.91**	24.20
	Commercial	0.92	1.56	1.37
	Industrial	0.31	0.61	4.00
	Public Semi public	5.363548	3.10	4.75
	Recreational	1.77	1.00	1.63
	Transportation	6.69	4.00	4.04
	Utility and services	0.46	0.56	1.02
	Vacant land	12.94	2.08	7.38
FAR	**Floor area Ratio**	**1.5**	**1.5**	**1.5**
S	Floor area requirement per Head	0.007968562	0.003575644	0.0061
	60% of developable area/ total area	35.7193908	19.1480904	29.666328

4.5 Amenities and open spaces



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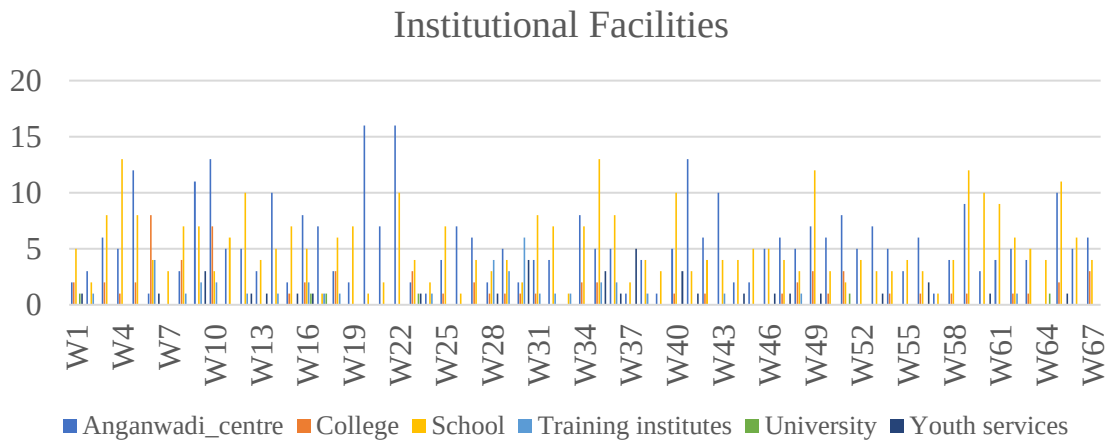

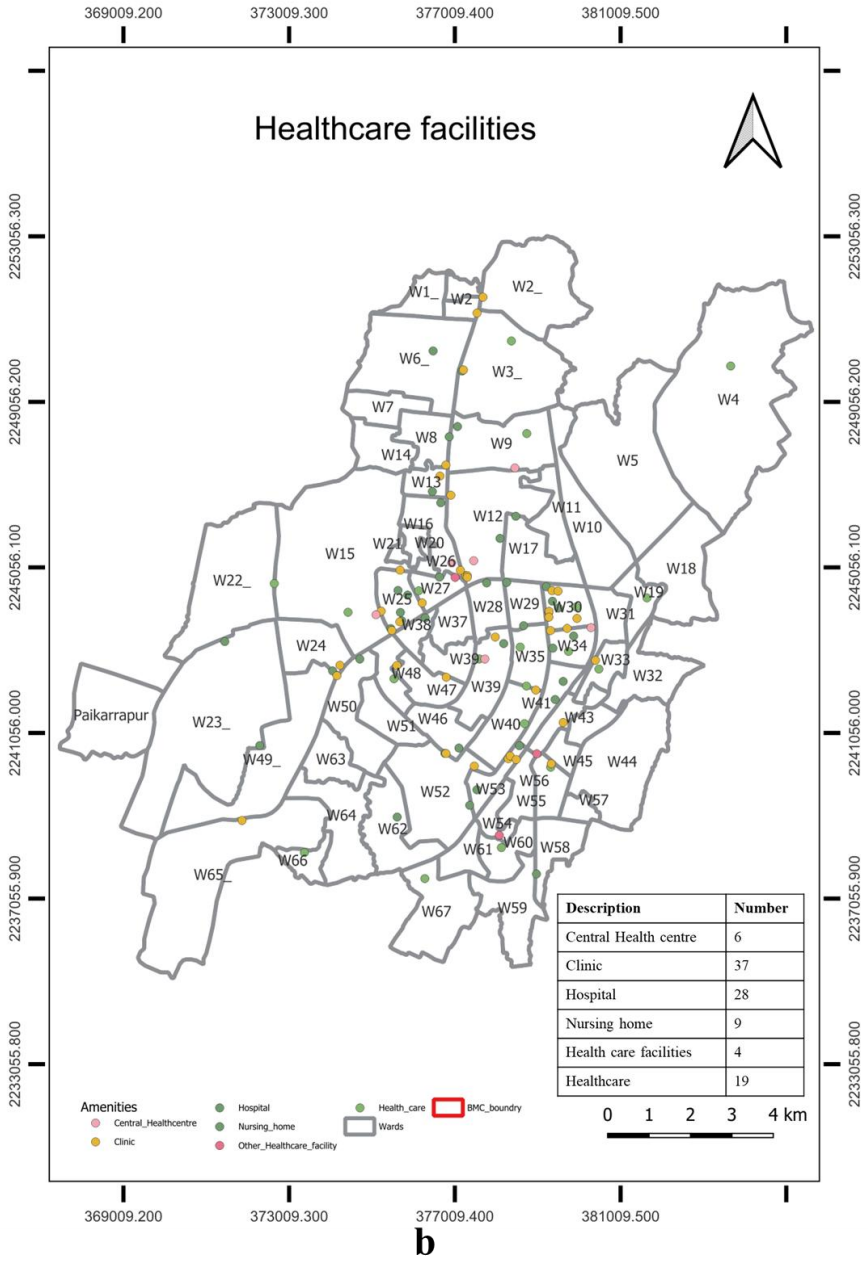
Healthcare facilities
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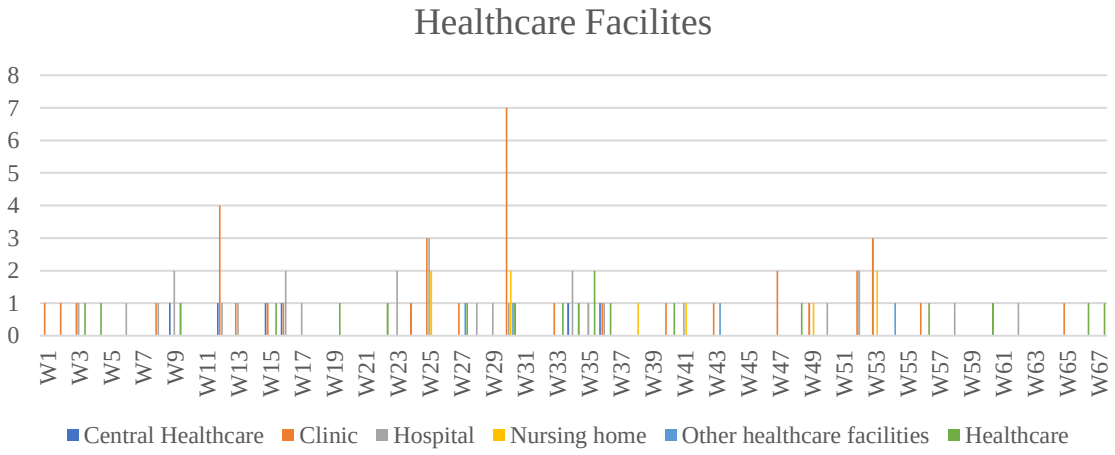
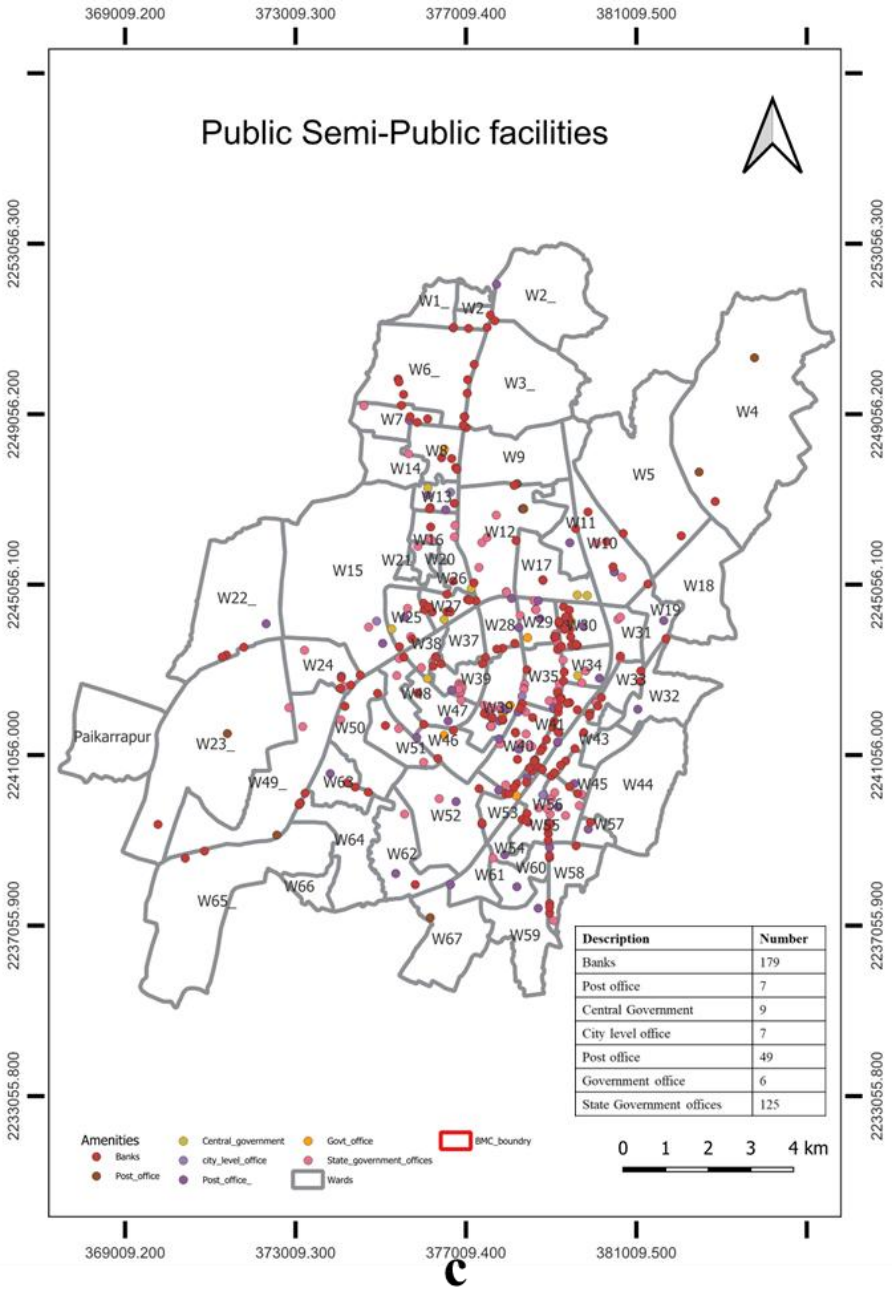
377009.400
381009.500
2253056.300
2249056.200
2245056.100
2241056.000
2237055.900
2233055.800
Paikarrapur
Description | Number
Central Health centre | 6
Clinic | 37
Hospital | 28
Nursing home | 9
Health care facilities | 4
Healthcare | 19
Amenities
Central_Healthcentre
Clinic
Hospital
Nursing_home
Other_Healthcare_facility
Health_care
Wards
BMC_boundry
0 1 2 3 4 km

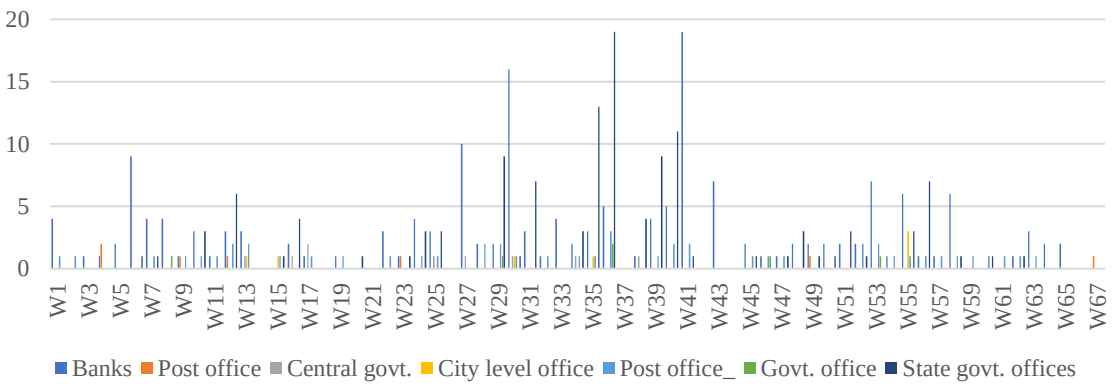
b

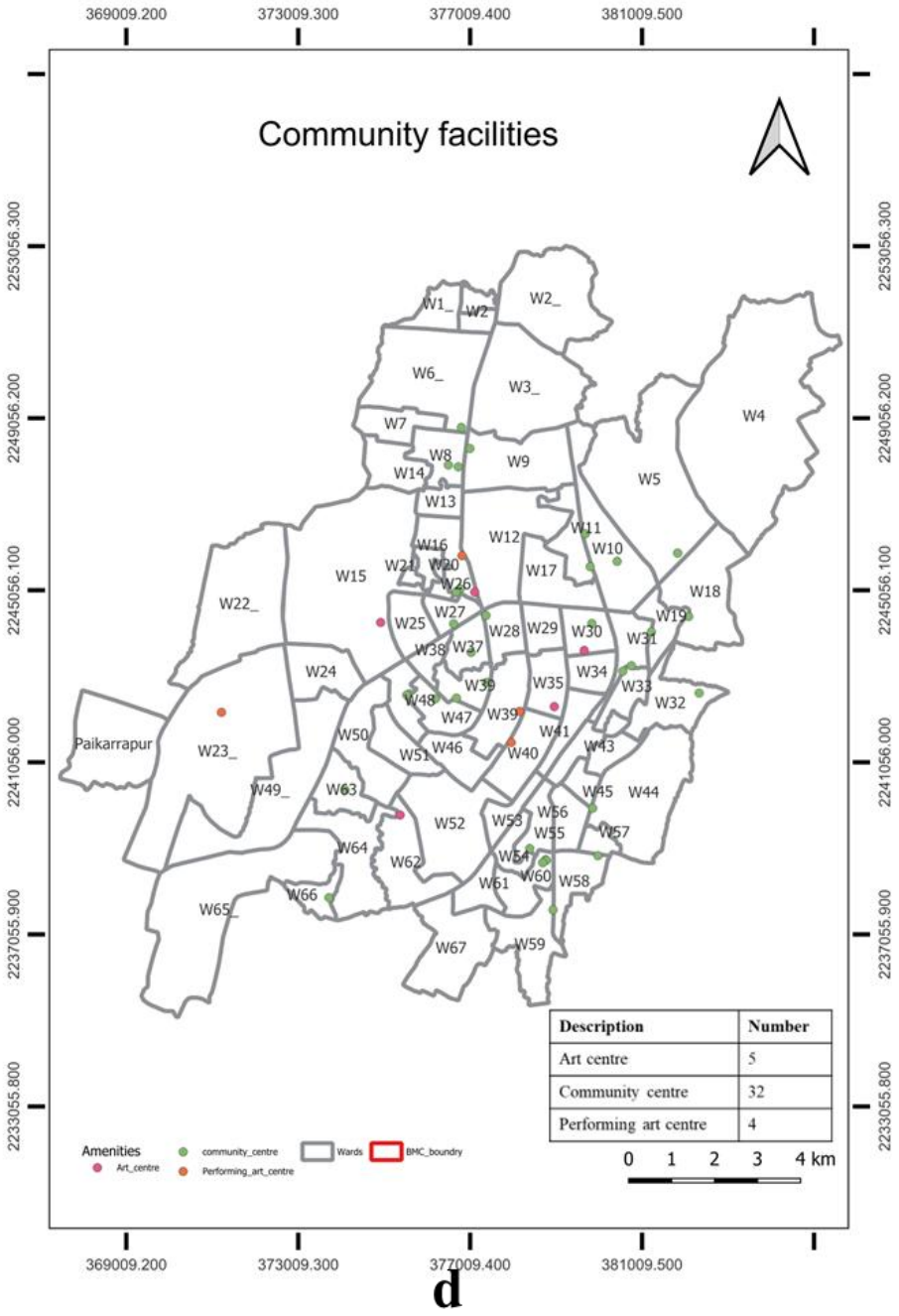

Healthcare Facilites
8
7
6
5
4
3
2
1
0
W1 W3 W5 W7 W9 W11 W13 W15 W17 W19 W21 W23 W25 W27 W29 W31 W33 W35 W37 W39 W41 W43 W45 W47 W49 W51 W53 W55 W57 W59 W61 W63 W65 W67
Central Healthcare
Clinic
Hospital
Nursing home
Other healthcare facilities
Healthcare



c

P SP facilities


20
15
10
5
0
W1 W3 W5 W7 W9 W11 W13 W15 W17 W19 W21 W23 W25 W27 W29 W31 W33 W35 W37 W39 W41 W43 W45 W47 W49 W51 W53 W55 W57 W59 W61 W63 W65 W67
Banks
Post office
Central govt.
City level office
Post office_
Govt. office
State govt. offices


Community facilities
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2253056.300
2249056.200
2245056.100
2241056.000
2237055.900
2233055.800
Paikarrapur
W1_
W2
W2_
W3_
W4
W5
W6_
W7
W8
W9
W10
W11
W12
W13
W14
W15
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W51
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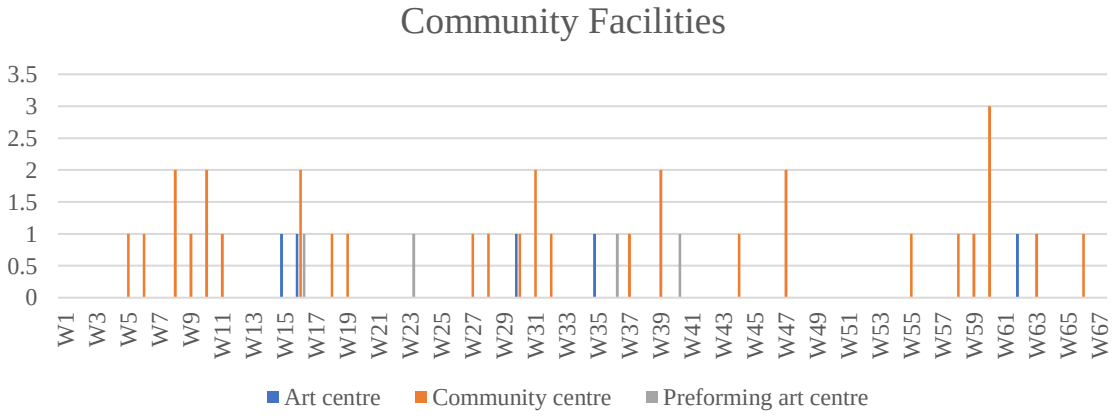
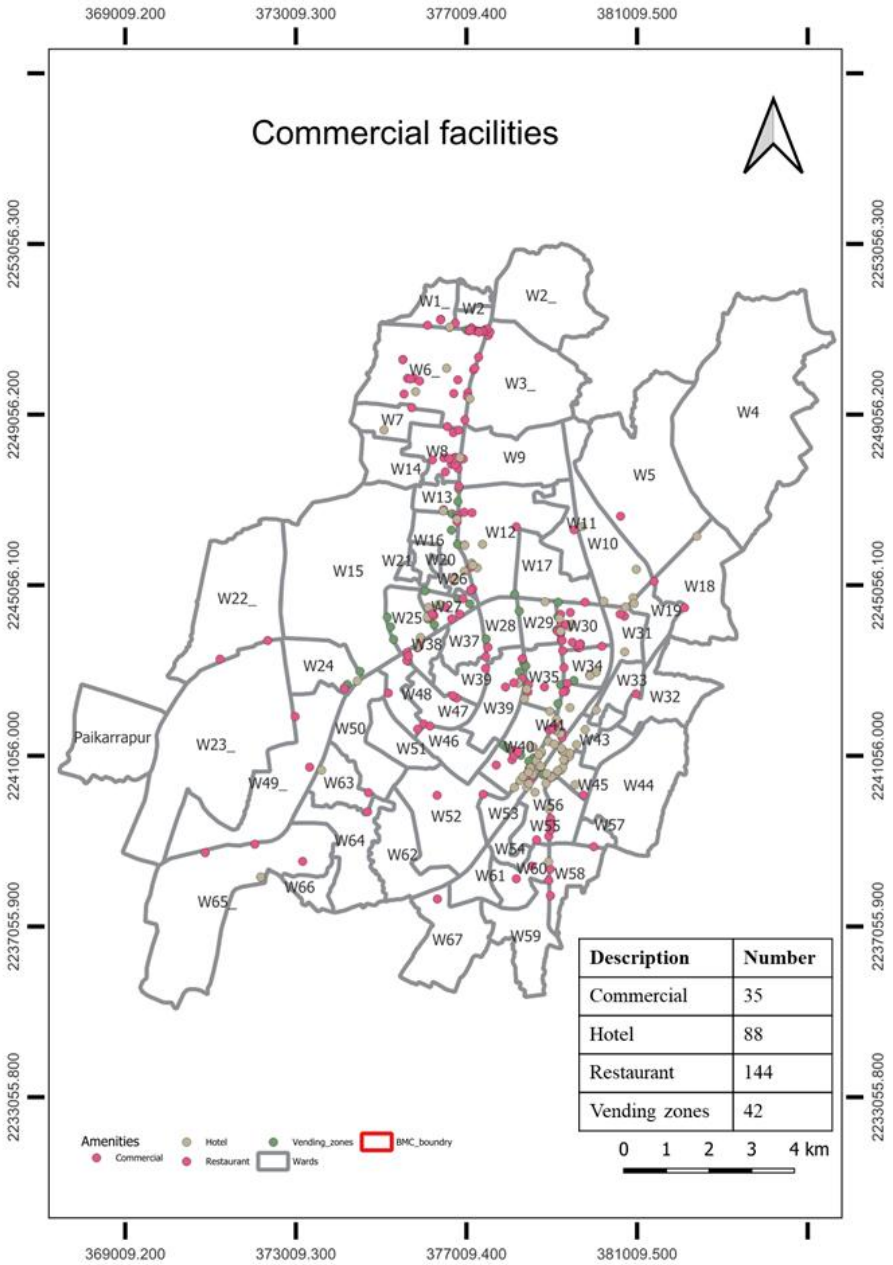
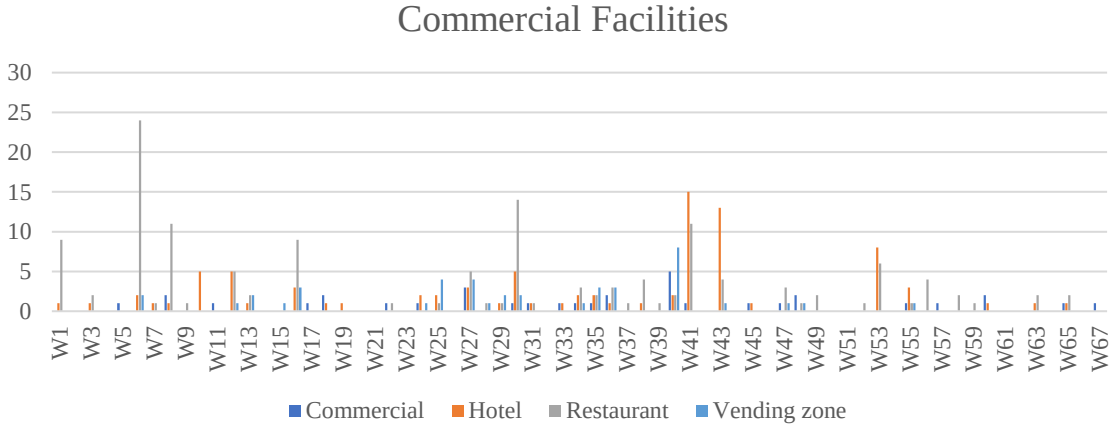
W53
W54
W55
W56
W57
W58
W59
W60
W61
W62
W63
W64
W65_
W66
W67
Description
Number
Art centre
5
Community centre
32
Performing art centre
4
Amenities
Art_centre
community_centre
Performing_art_centre
Wards
BMC_boundry
0 1 2 3 4 km

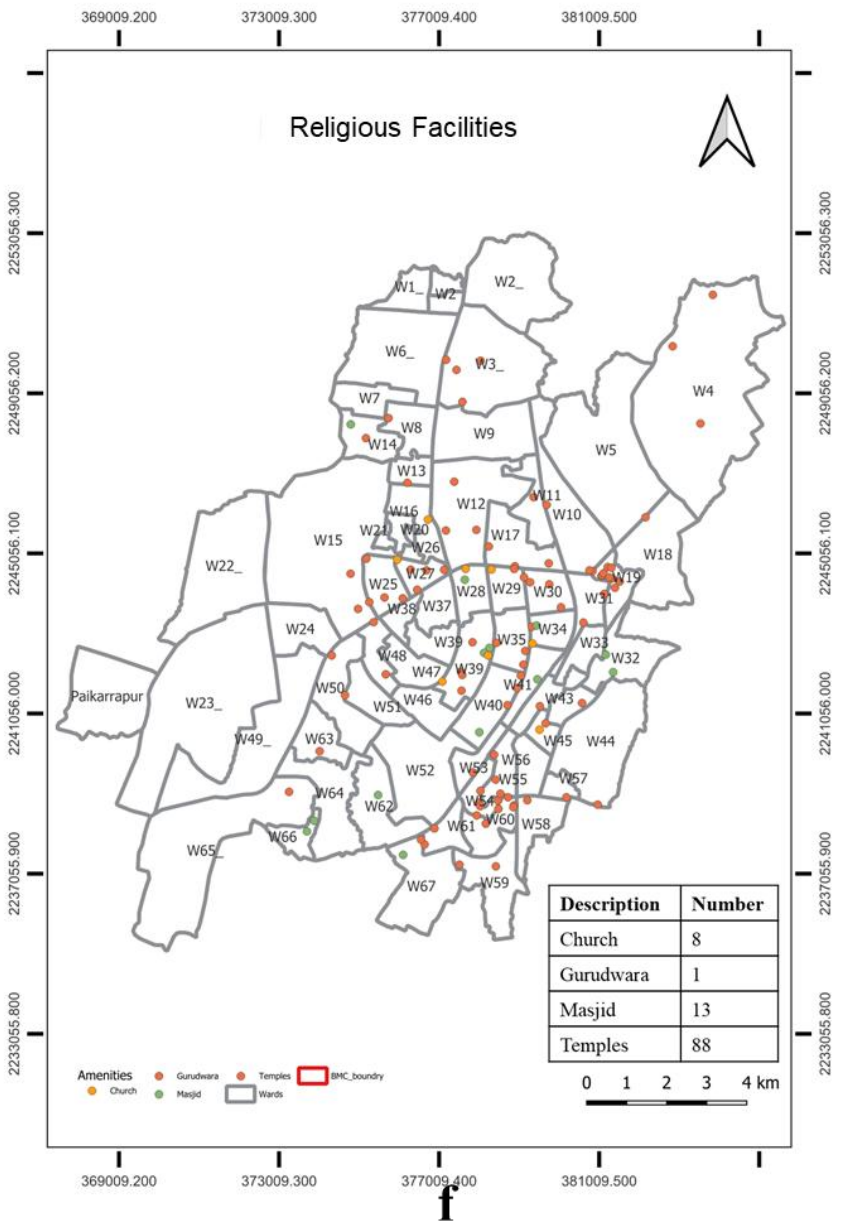
d


Community Facilities
3.5
3
2.5
2
1.5
1
0.5
0
W1 W3 W5 W7 W9 W11 W13 W15 W17 W19 W21 W23 W25 W27 W29 W31 W33 W35 W37 W39 W41 W43 W45 W47 W49 W51 W53 W55 W57 W59 W61 W63 W65 W67
Art centre
Community centre
Preforming art centre

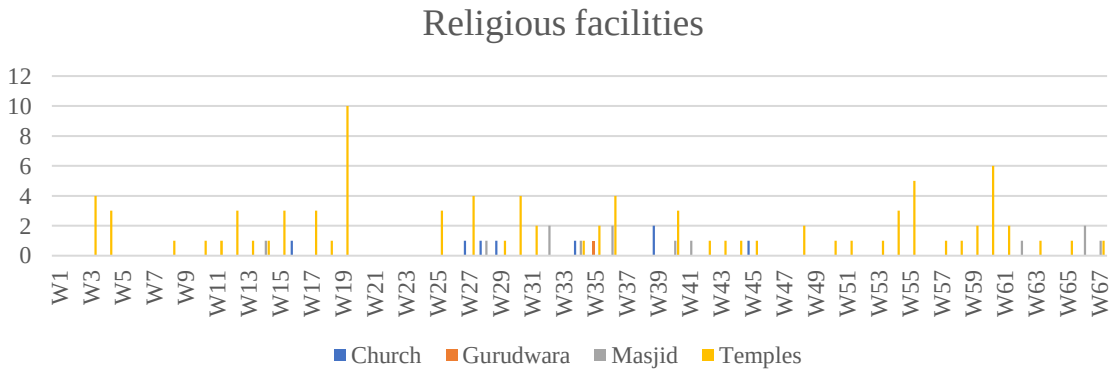

Commercial facilities
369009.200
373009.300
377009.400
381009.500
2253056.300
2249056.200
2245056.100
2241056.000
2237055.900
2233055.800
Paikarrapur
Description | Number
Commercial | 35
Hotel | 88
Restaurant | 144
Vending zones | 42
0 1 2 3 4 km
Amenities
Commercial
Hotel
Restaurant
Vending_zones
Wards
BMC_boundry

e


Commercial Facilities
30
25
20
15
10
5
0
Commercial
Hotel
Restaurant
Vending zone



f



Map 29 Amenities within the city- a. Institution facilities, b. Healthcare facilities, c. Public Semi-Public Facilities, d. Community facilities, e. Commercial facilities, f. Religious Facilities.

From the maps (Map 29 a), it can be observed that institutional facilities are distributed throughout the city; however, some peripheral wards-such as wards 2, 22, 23, 44, and 65 lack this infrastructure. Healthcare facilities (Map 29 b) are available within the city but are primarily concentrated in certain wards located in Zones 2 and 3, while Zone 1 has limited healthcare infrastructure. Public semi-public facilities (Map 29 c) are mainly concentrated in Zones 2 and 3, although some are also present in Zone 1.

Upon examining the maps of community, commercial, and religious facilities (Map 29 d,e,f), it is evident that there are community facilities in the city but concentrated in some wards like 6, 8, 9, 20, 26, 27, 37, 38, 47, and 48. Commercial facilities are also concentrated and are developed mostly in Zone 2 and Zone 3, with insufficient commercial infrastructure in Zone 1. Religious establishments are scattered across the city, with barely any wards in the west and south-west missing these institutions. This is an indication of requiring more balanced allocation of community and commercial facilities, in accordance with urban planning principles that advocate for even access to basic services within all zones of the city.

Open/Green areas

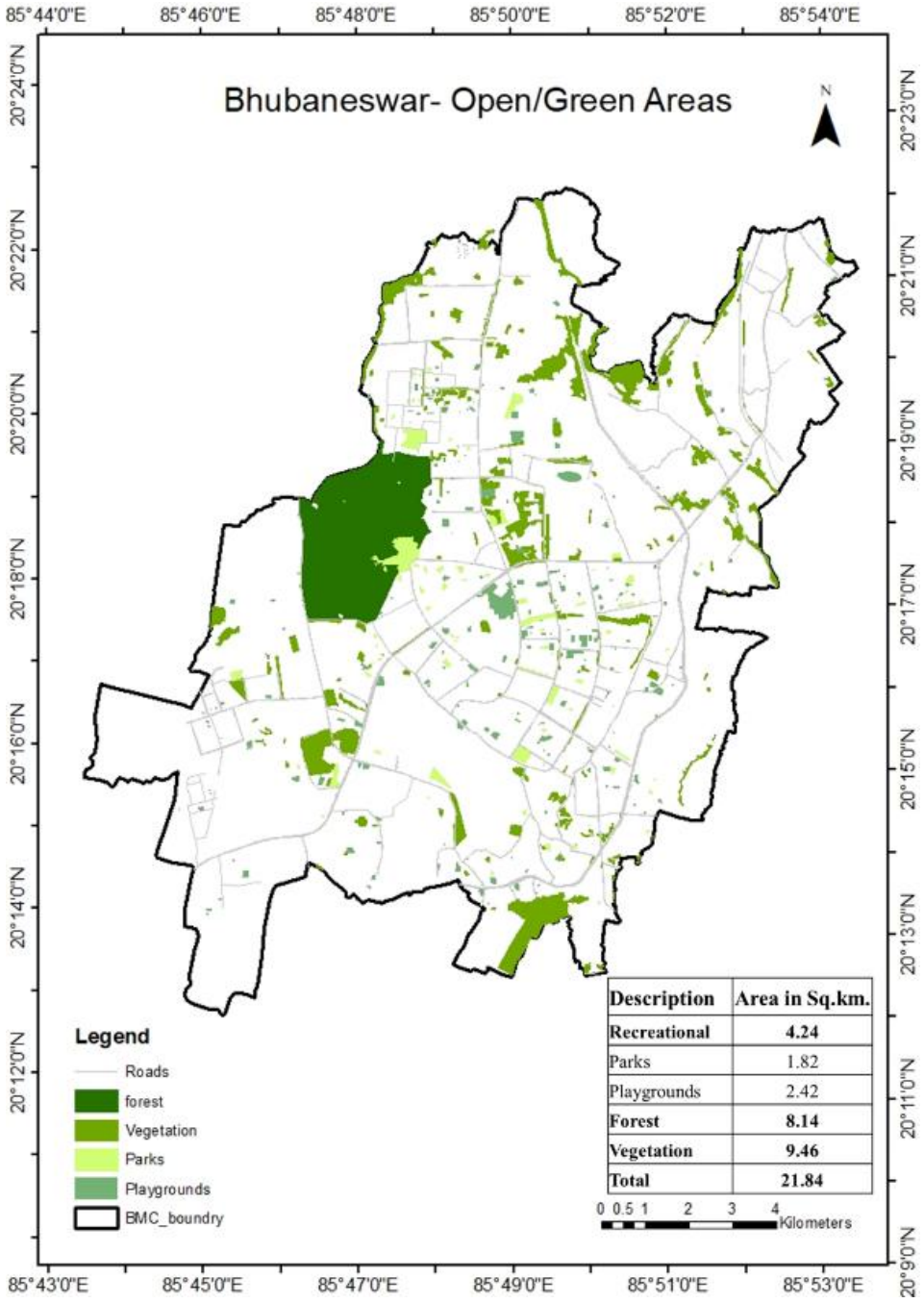
Map 30 shows the open and green areas within the city, including forests, recreational spaces such as parks and playgrounds, and vegetation or green cover.

Table 20 Open/green area requirement as per land requirement of land use

Land use						
Description	**Area in sq.km.**	**Acres**	**Percentage**	**URDPFI 2014**	**Remark**	**Required**
Recreational	4.24	1047.7	2	14-16	Shortage	29.76 sq.km.

The map (map 30, table 20) indicates that recreational areas within the city constitute only 2% of the total land, whereas the URDPFI guidelines recommend that 14–16% of land should be allocated for recreational use. This highlights a significant shortfall in the provision of recreational facilities. Additionally, the URDPFI guidelines specify that urban

areas should have a minimum of 10 to 12 square meters of open space per person. Based on current land-use data for 2025, the city has 21.84 sq. km of green/open areas.



Map 30 Open/Green areas

However, calculations show that by 2031, given the projected population, the city will not meet the recommended standards for green and open spaces, indicating a pressing need to enhance such facilities to accommodate future growth (table 21).

Table 21 Open/Green area required per person according to URDPFI

YEAR	Population	URDPFI	Area required in sq.km.
2011	8,40,834	Minimum of 10 to 12 square meters of open space per person in urban areas	10.09
2021	12,87,597		15.45
2031	19,71,740		23.66
2041	30,19,391		36.23
2051	46,23,693		55.48

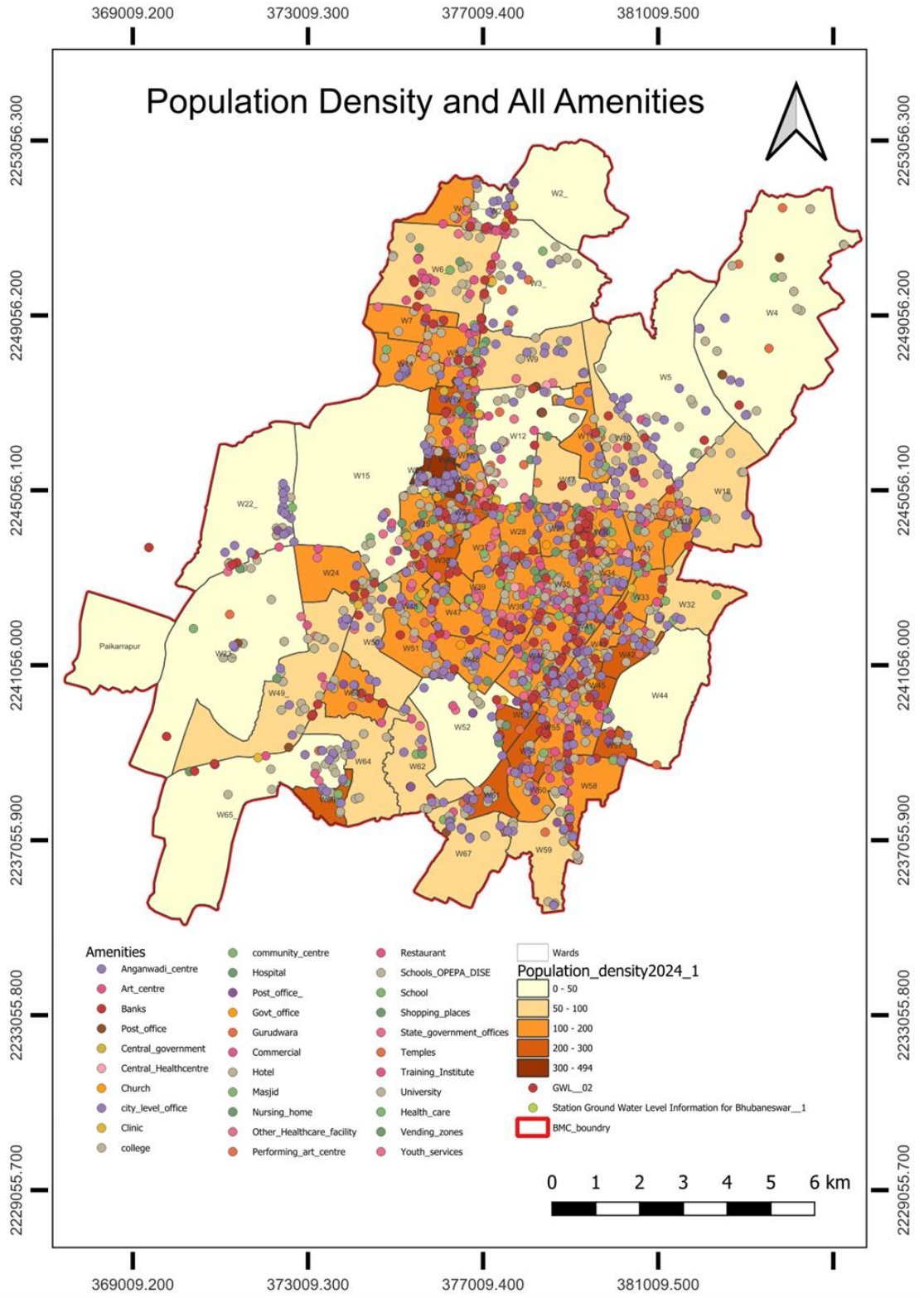
4.6 Inferences

Till now the individual analysis has been done, like analysis of amenities, infrastructure, such as water network and sewerage network, land prices and population density. To analyse it together by overlapping it provides insightful analysis about the city's characteristics, and why population, land prices are higher in certain wards, whereas less in peripheral wards.

4.6.1 Population Density and amenities

This analysis explores three indicators: infrastructure, amenities, and population density. The first map (Map 31 a) shows the relationship between population density and amenities. From which, it was evident that places with a high concentration of amenities have higher population densities, whereas the outer peripheries, where there are limited amenities, tend to have lower densities. There are exceptions, however; e.g., wards 3, 4, 22, and 23 contain amenities despite having low population densities. This implies that other factors like the availability of vacant or agricultural land in wards 4, 23, 44, and 65 also affect population density as well as the provision of amenities.

The map (Map 31 b) to the right illustrates the interconnection of infrastructure, amenities, and density of population. It is visible that areas of high-developed infrastructure will be more developed, aided by greater amenities. Areas that lack infrastructure develop at a slower pace or can have limited growth, which can be observed from lower densities of population.


Population Density and All Amenities
369009.200
373009.300
377009.400
381009.500
2253056.300
2249056.200
2245056.100
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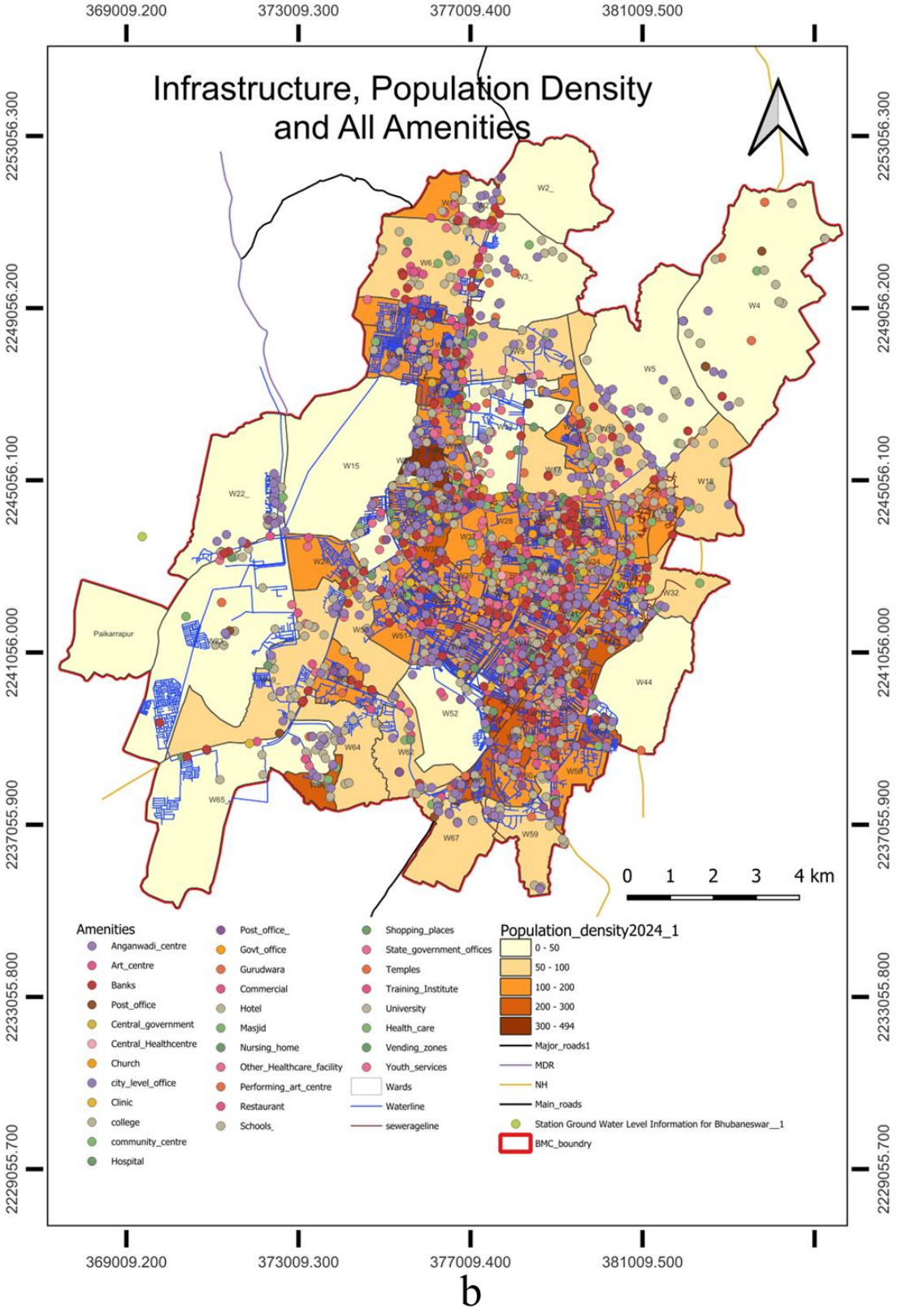
2237055.900
2233055.800
2229055.700
Paikarrapur
Amenities
Anganwadi_centre
Art_centre
Banks
Post_office
Central_government
Central_Healthcentre
Church
city_level_office
Clinic
college
community_centre
Hospital
Post_office_
Govt_office
Gurudwara
Commercial
Hotel
Masjid
Nursing_home
Other_Healthcare_facility
Performing_art_centre
Restaurant
Schools_OPEPA_DISE
School
Shopping_places
State_government_offices
Temples
Training_Institute
University
Health_care
Vending_zones
Youth_services
Wards
Population_density2024_1
0 - 50
50 - 100
100 - 200
200 - 300
300 - 494
GWL__02
Station Ground Water Level Information for Bhubaneswar__1
BMC_boundry
0 1 2 3 4 5 6 km

a

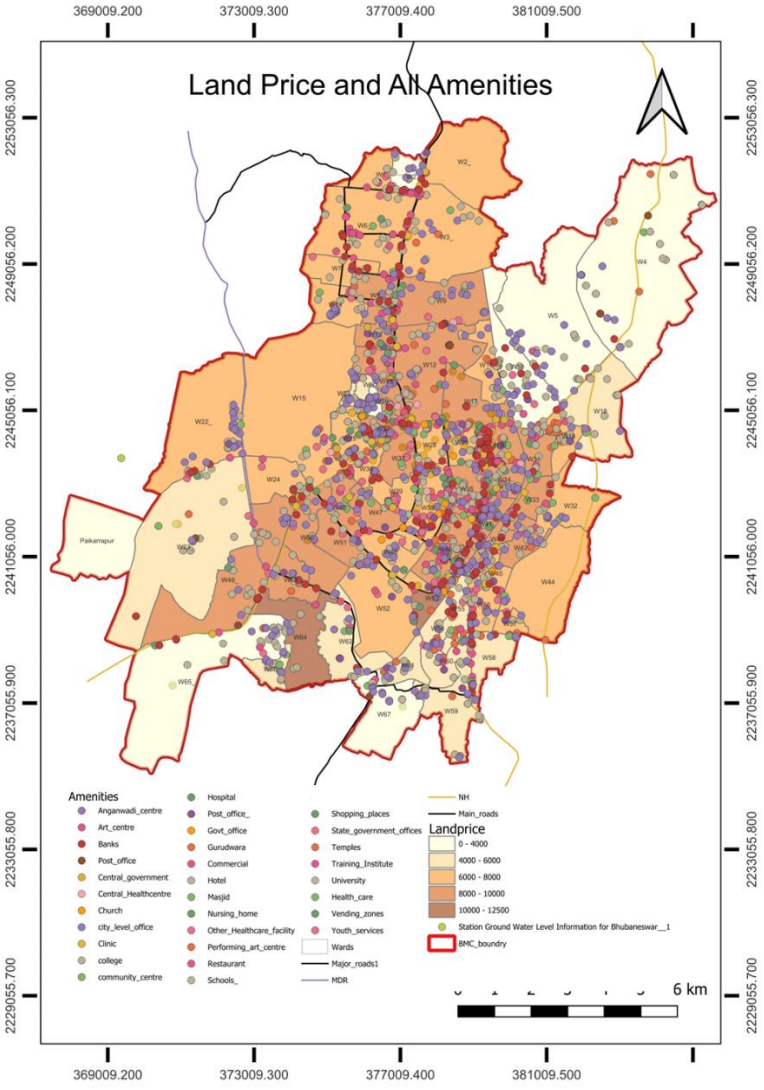


Map 31 a. Population Density and amenities; b. Infrastructure, Population density, and Amenities

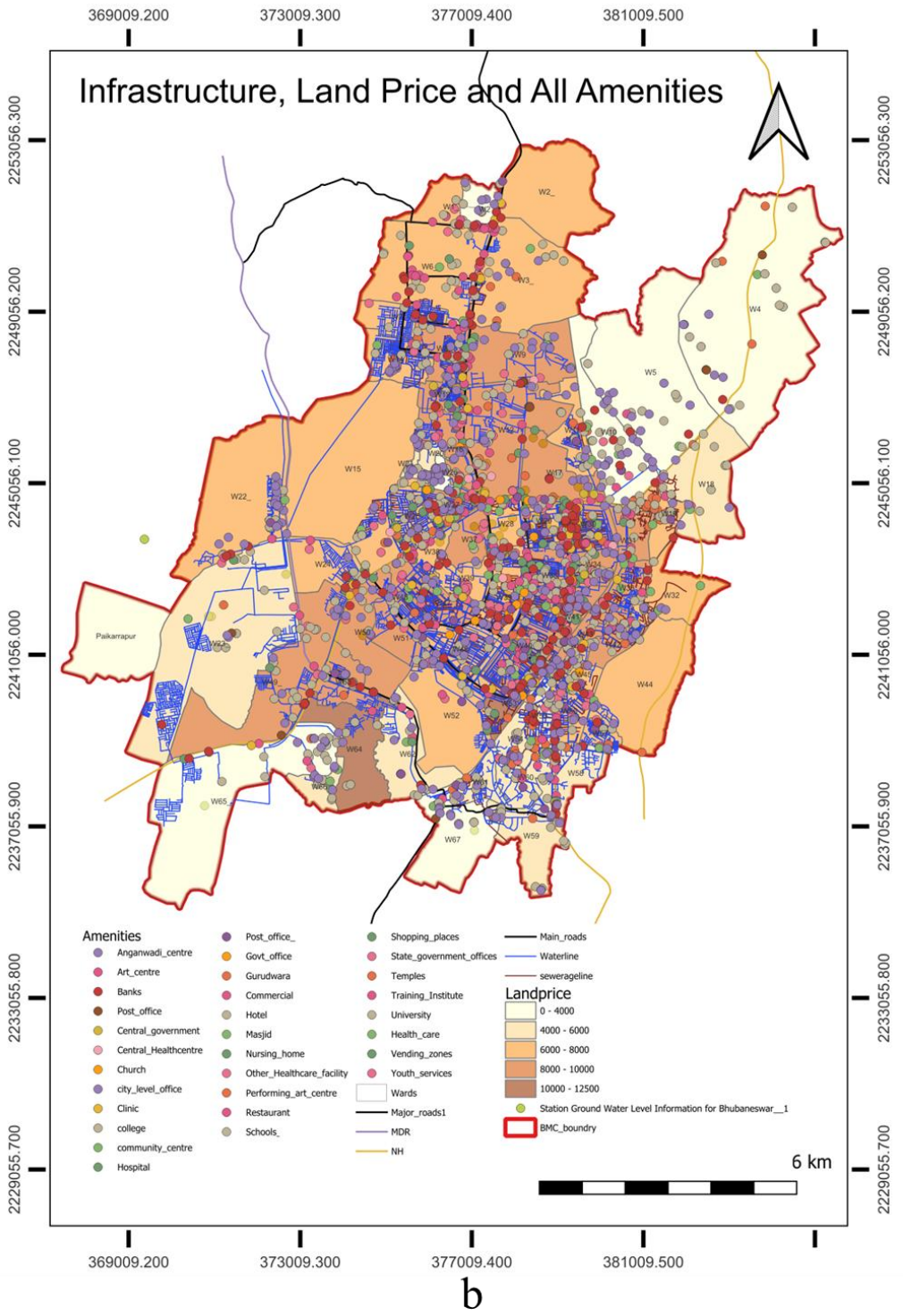
But it should be noted that while infrastructure and amenities are positively related to increased density and development, other factors-such as land use and socioeconomic status-also play a big role in these processes.

4.6.2 Land Price and amenities

In the previous section, an analysis was conducted using three indicators: population density, amenities, and infrastructure. Similarly, this section analysis the relationship between amenities, land prices, and population density. By overlaying these indicators, the analysis provides valuable insights into the city's characteristics. It is observed that amenities and population density are positively associated, and both factors influence land prices, higher amenities and density often lead to increased land values, especially in central urban areas.



a



b

Map 32 a. Land price and amenities; b. Infrastructure, Land price, and amenities;

Map 32(a) illustrates the correlation between amenities and land prices, and Map 32(b) illustrates the aggregate relationship of land price, amenities, and infrastructure. The map reveals that areas with amenities and good infrastructure possess high land prices, while areas without these features have low land prices. The trend depicts the primary role played

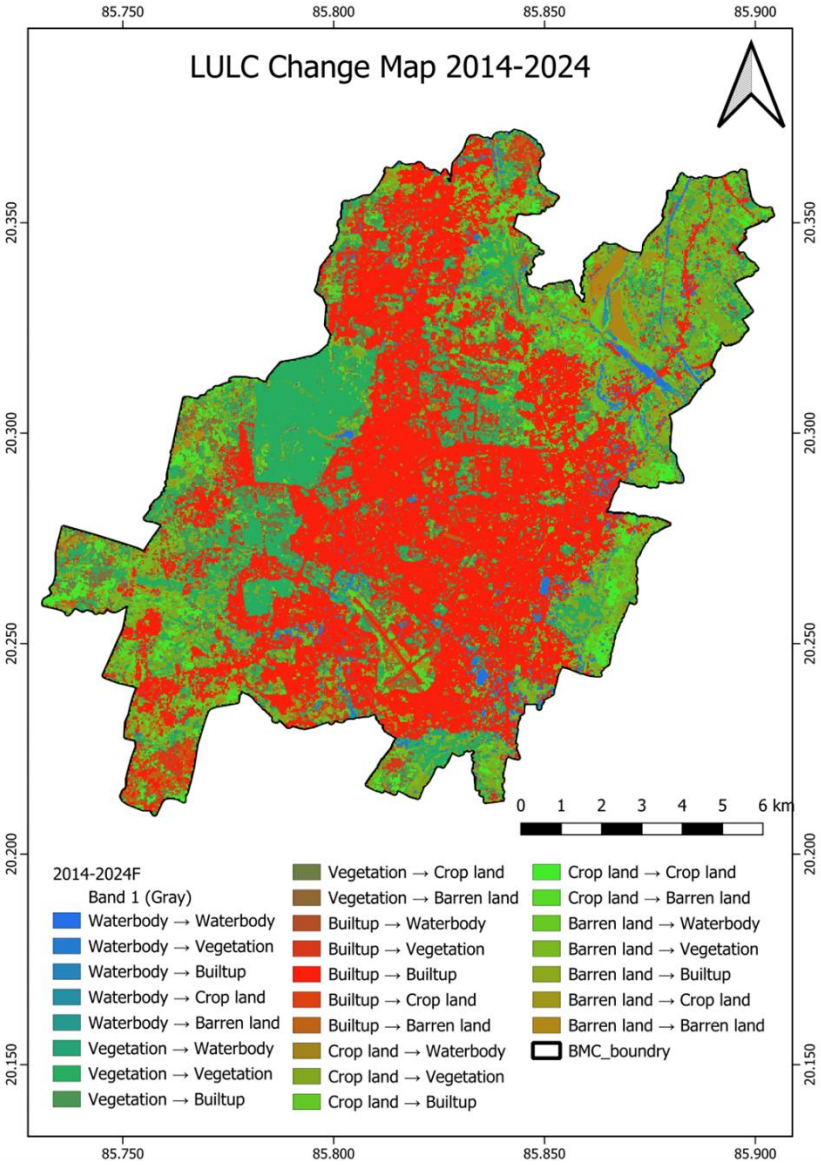
by infrastructure and amenities in determining land values and urban growth. It is determined that improved infrastructure-including transport networks such as roads, public transport, and utilities-and access to amenities make areas more desirable, increase demand, and lead to increasing land and property prices. Where there is no infrastructure or its development is poor, growth is reduced and the worth of land is lower. This data corroborates the argument that infrastructure is an integral part of a city's expansion; as does infrastructure and amenity quality, and so do land values and development activity.

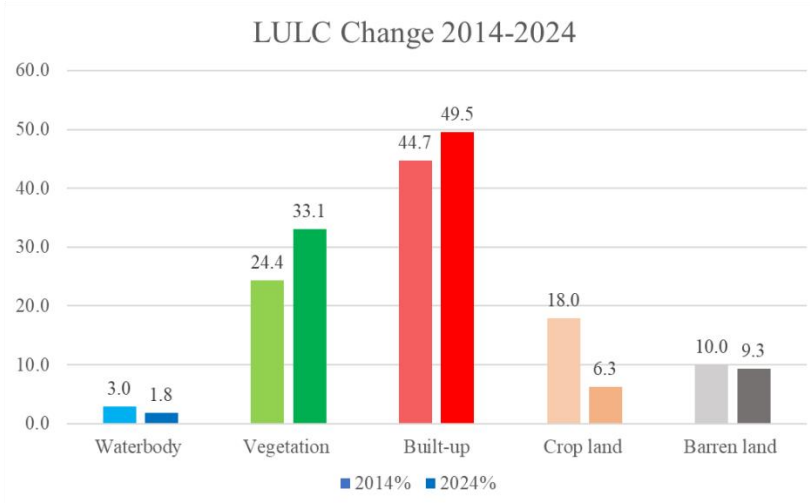
4.6.3 LULC transition

Land Use and Land Cover (LULC) transition refers to the changes in the way land is utilized or the natural cover it has over time, for example, when Forest is converted to Agricultural land or Urban land. LULC change would need to be examined because it tells us about how human activities and natural processes are reconfiguring the environment, more rapidly at rates never seen before. This is because such understanding is critical in effective land management and green growth as it equips planners and policymakers with the information to make decisions about resource distribution, urbanization, and conservation priorities. Furthermore, the examination of LULC variations provides crucial information for monitoring environmental changes, policy-making, and guaranteeing that land use sustains ecosystem equilibrium and human well-being.

A. 2014-2024

The Land Use and Land Cover (LULC) transition analysis over the past decade reveals a reduction in water bodies, cropland, and, to a lesser extent, barren land, alongside an increase in vegetation and built-up areas (see Map 33). Table 22 details these land-use transitions. Prominently, a large portion of cropland has been converted into built-up areas, while waterbodies have transitioned into both vegetation and built-up land. Moreover, some vegetation has been transformed into built-up areas, and barren land has shifted to vegetation and built-up uses.





Map 33 LULC change map 2014-2024

Table 22 Transition matrix 2014-2024

Transition matrix					
	Waterbody	**Vegetation**	**Built-up**	**Crop land**	**Barren land**
Waterbody	0.180	0.394	0.348	0.025	0.053
Vegetation	0.007	0.649	0.169	0.062	0.113
Built-up	0.008	0.104	0.838	0.014	0.037
Crop land	0.025	0.407	0.255	0.170	0.144
Barren land	0.029	0.415	0.235	0.102	0.220

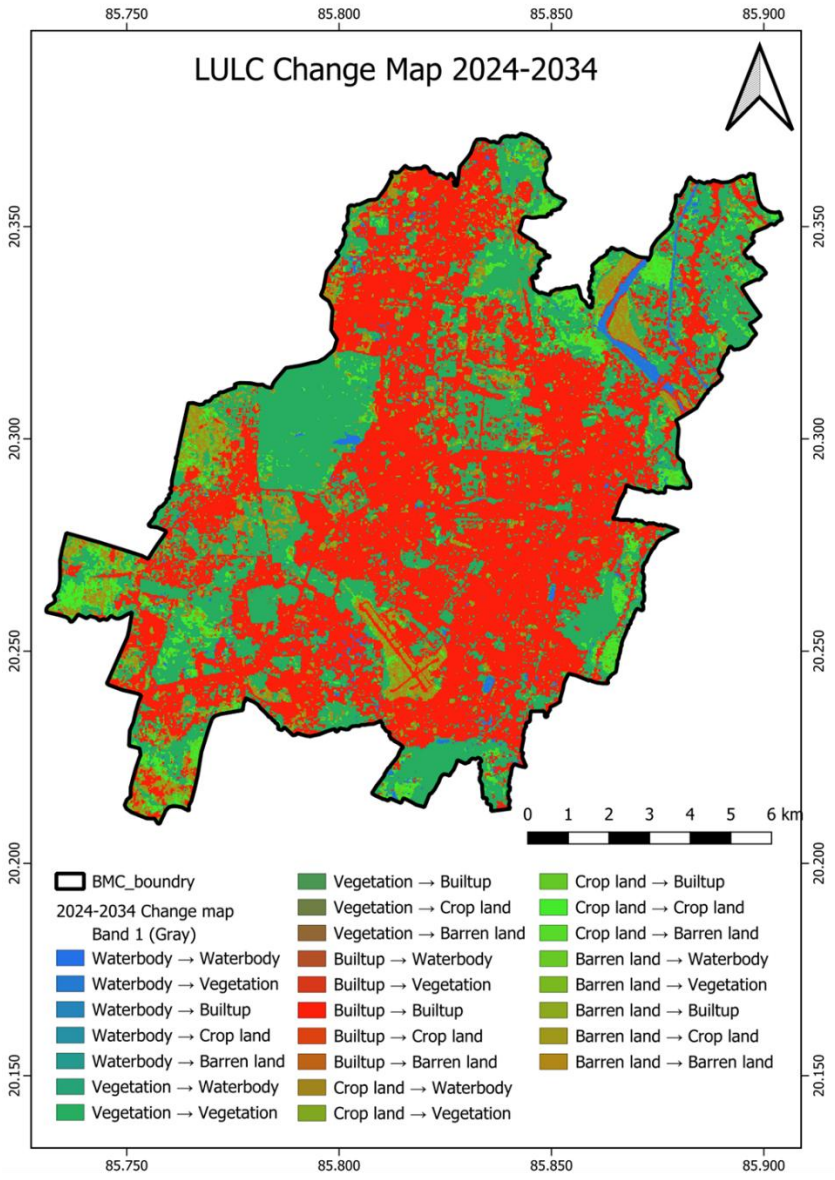
B. 2024-2034

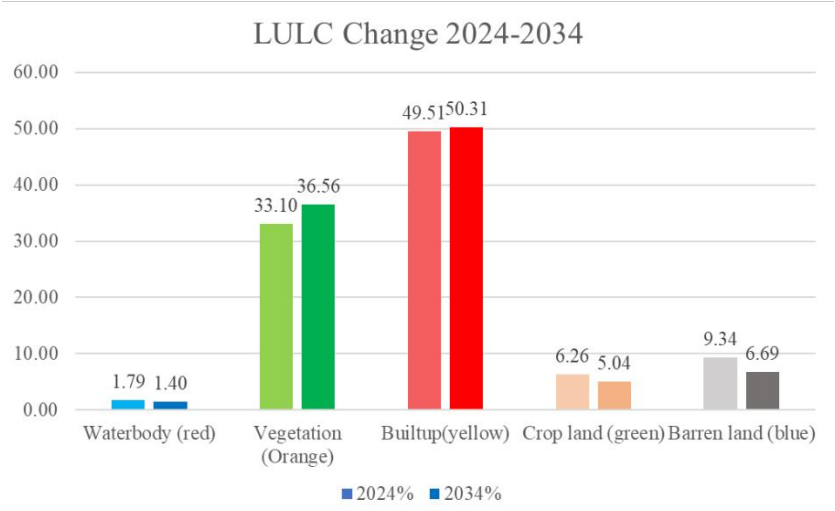
The decadal change analysis was carried out employing the MOLUSCE plugin in QGIS to evaluate the transitional land use and land cover changes. This also allows for not only the evaluation of past and present change but future trends prediction and identifying the direction of the city's development.

Based on Map 34, it can be observed that the extent of LULC transition is lower compared to the previous decade’s analysis. In this period, barren land has decreased significantly, while cropland and waterbodies have seen only minor reductions. Increases in vegetation and built-up areas are also comparatively less. As shown in Table 23, most of the cropland has been converted to built-up land.

Table 23 Transition matrix 2024-2034

Transition matrix					
	Waterbody	**Vegetation**	**Built-up**	**Crop land**	**Barren land**
Waterbody	0.780	0.168	0.043	0.000	0.009
Vegetation	0.000	0.998	0.002	0.000	0.001
Built-up	0.000	0.004	0.996	0.000	0.000
Crop land	0.000	0.089	0.103	0.806	0.001
Barren land	0.000	0.267	0.024	0.000	0.709





Map 34 LULC change map 2024-2034

4.6.4 Future Prediction map of 2034 and 2044

After analysing the LULC transitions, the future prediction maps (Map 35) are produced using the MOLUSCE plugin in QGIS. MOLUSCE (Modules for Land Use Change Evaluation) employs historical land cover and use data along with spatial parameters such as distance from roads and elevation to model and simulate how land use patterns are going to change in the future using algorithms including Artificial Neural Networks and Cellular Automata. This predictive mapping method is useful for urban planning and sustainable land use planning, as it offers spatial visualization of the likely direction and magnitude of the city's growth and determination of areas at risk of rapid development or environmental change. Such long-sightedness is crucial for planner, policymaker, and environmental manager since it enables the prediction of possible future problems, prioritization of areas of intervention, and planning suggestions on the basis of projected trends.

Analysis of the prediction maps for 2034 and 2044 indicates that the most significant growth is concentrated on the South, South-East, and South-West sides of the city, with some infill development also observed on the North side. The majority of new development in the Southern and South-Eastern extremes is primarily occurring on agricultural land. Additionally, areas near the airport are experiencing infill development.

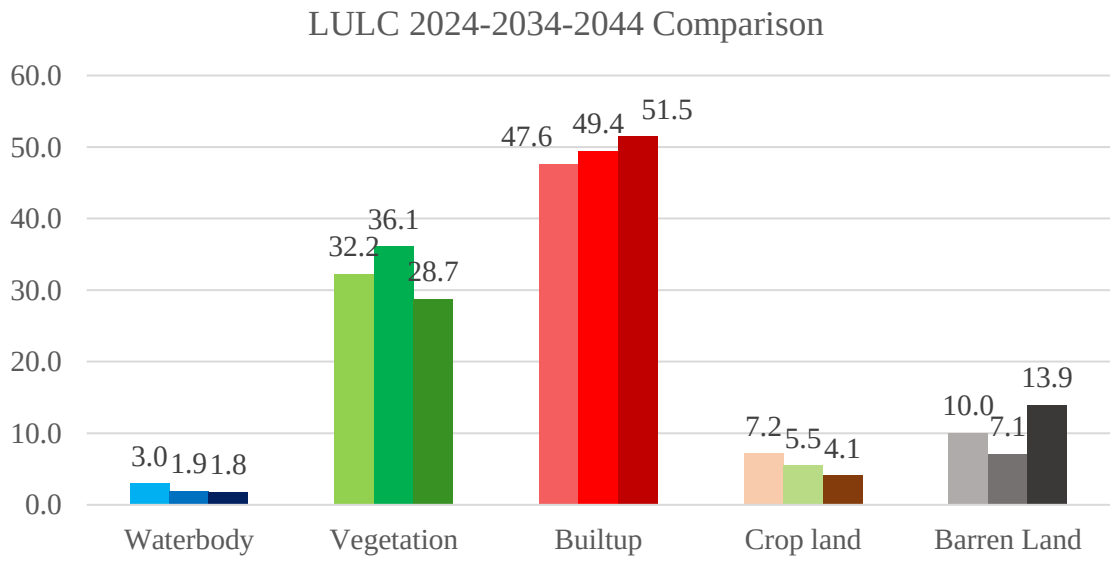
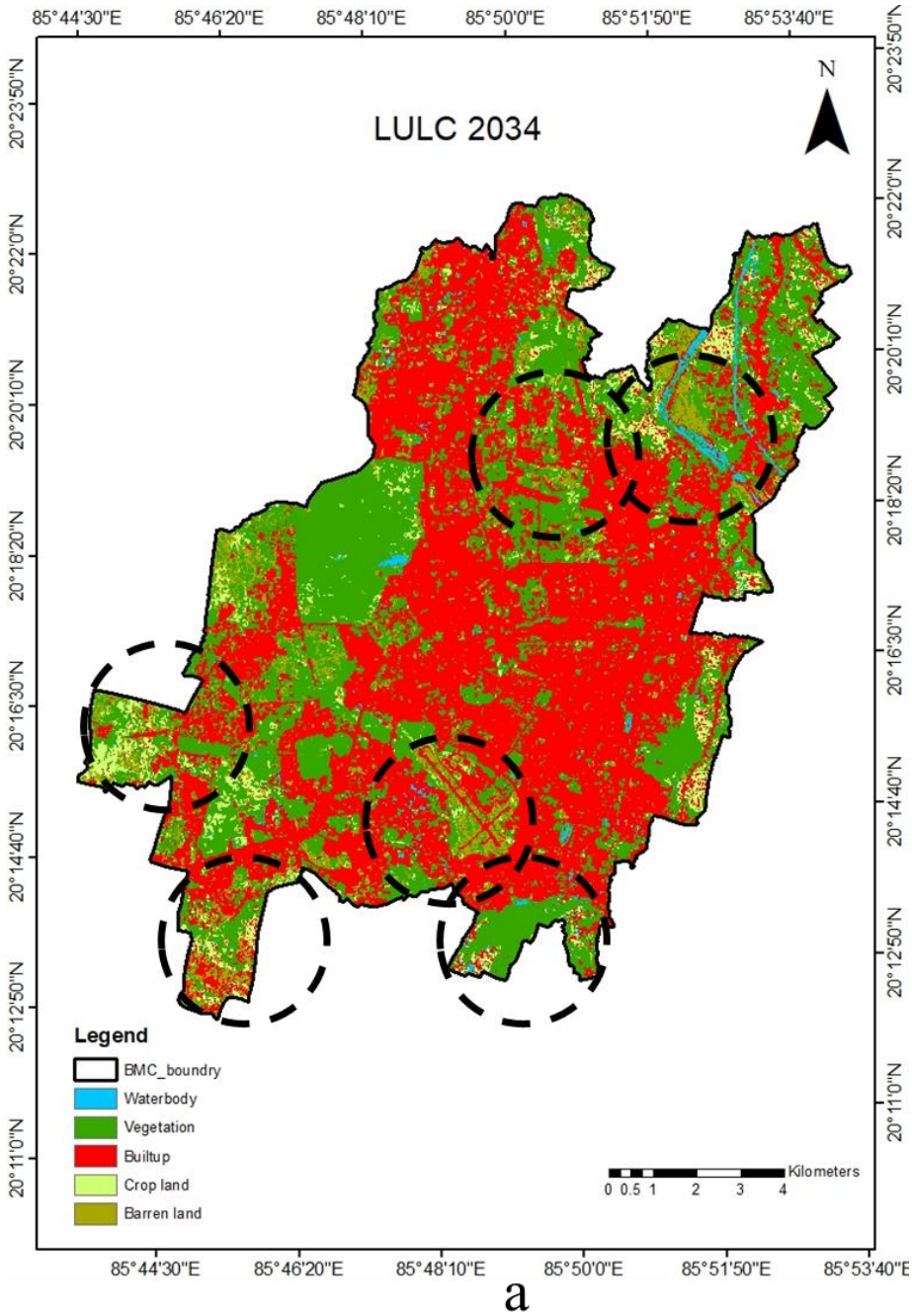


Figure 17 Future Prediction map 2024, 2034 and 2044.

Analysis: Analysis of built-up growth (Map 8) shows that, up to 2024, urban expansion has primarily occurred on the South-West side of the city, with no significant growth

observed towards the west. Future prediction maps indicate that development is expected to continue in the South-East, South, and South-West directions. Some infill development is also anticipated on the north side. The future prediction map also indicates a decrease in vegetation and crop land, with an increase in Built-up and barren land, reflecting continuing urbanization and the transformation of cultivated and green areas into developed or unused land (fig. 17).



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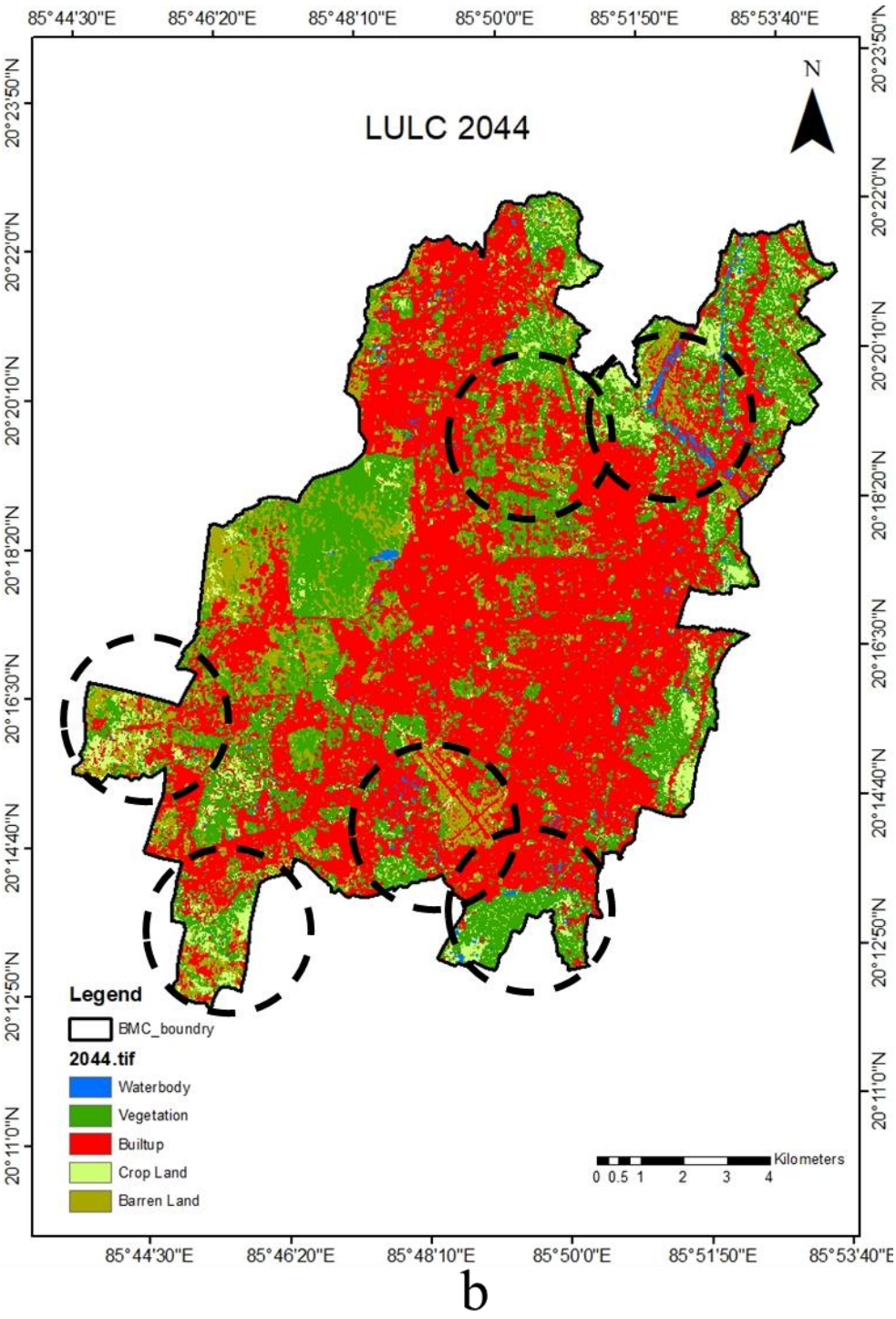
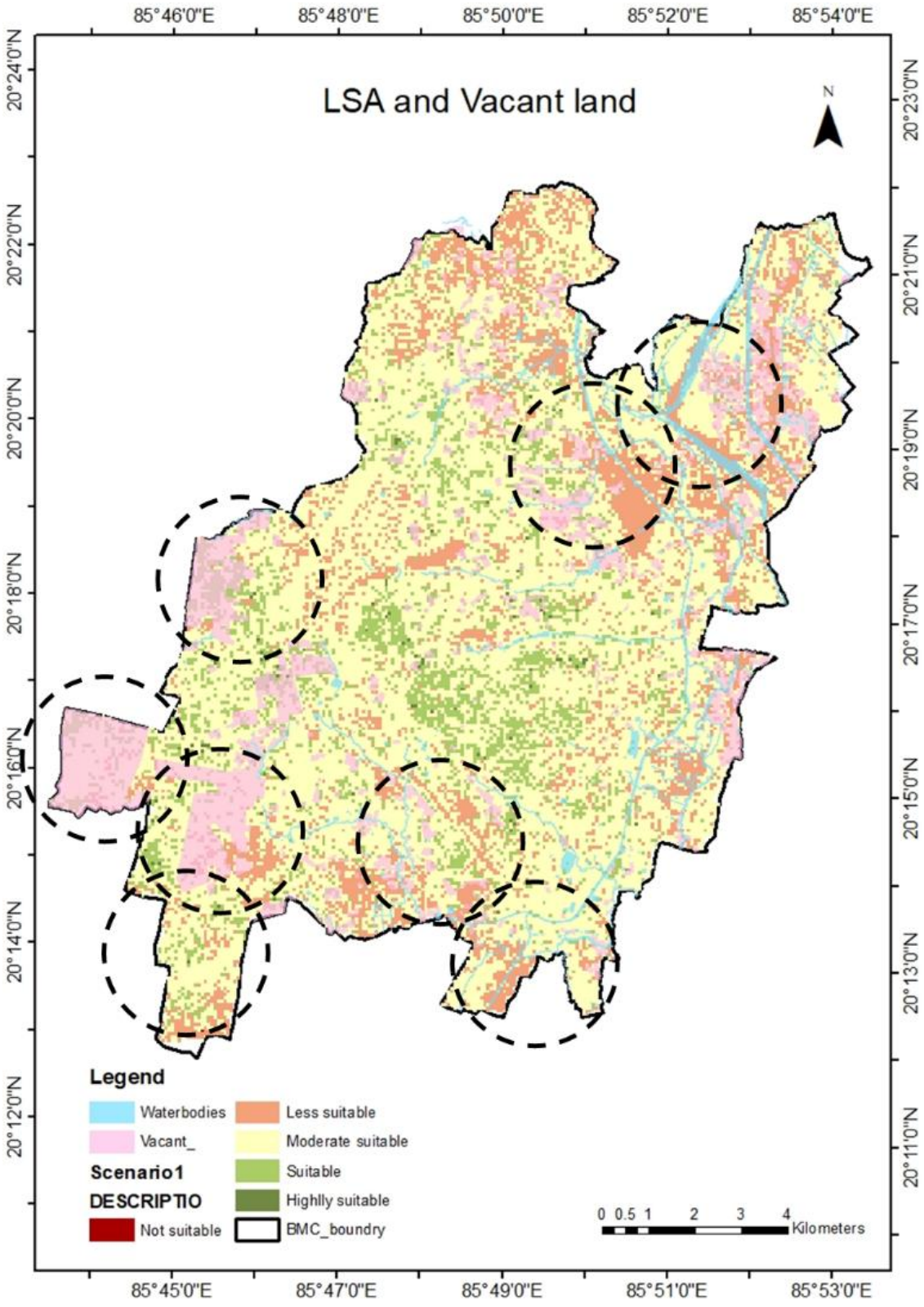


Map 35 Future Prediction map a. 2034 and b. 2044.

4.6.5 LSA and Vacant land analysis



Map 36 LSA and Vacant land analysis

The LSA (Land Suitability Analysis) map has been overlayed on the vacant lands (Map 36), and data on how much of the vacant land is in each category of suitability is given, as shown in Table 24. This method assists planners and decision-makers in determining and measuring the available land suitability for different uses and facilitating informed urban development and sustainable land management.

Table 24 Vacant land categorisation

Description	**Area in Sq.km.**	**Percentage**
Total Vacant Land	22.16	12% (Total City area)
Vacant land under less suitable category	2.32875	10.51 (From vacant land)
Vacant land under Moderate suitable category	15.7	70.84 (From vacant land)
Vacant land suitable Category	4.02	18.14 (From vacant land)
Vacant land highly suitable Category	0.1125	0.51 (From vacant land)

Land Ownership

Approximately 40% of the vacant lands are categorized as government land, and the other 60% are private land. Nevertheless, according to the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act (LARR), different TP schemes, land pooling, or any other land management scheme, the government can, according to law, acquire private land for public purposes, such as urbanization and economic development.

A framework of law for using private land for systematic urban development is also introduced by the Odisha Development Authorities (Planning and Building Standards) Rules, 2020 and the Odisha Development Authorities Act, 1982. Empowering the authorities with the authority to acquire or negotiate using private land for schemes that are in the interest of the city, these laws ensure that the necessary land resources are mobilised sufficiently for development and infrastructure schemes.

There are certain sections from Odisha Development Authorities (Planning and Building Standards) Rules, 2020 which informs about private land can be utilized for development and the city's welfare (table 25).

Table 25 Norms/Policies/Strategy/Act

Norms/Policies/Strategy/Act			
Section		**Key Provisions & Powers**	**Significance for Urban Development**
Odisha Development Authorities (Planning and Building Standards) Rules, 2020			
3 & 4	Declaration of Development Areas and Constitution of Authority	- State Govt. notifies areas as "development areas". - All land (private as well) in such areas comes under the planning controls of the Act. - State Govt. forms a Development Authority as a corporate entity with powers to purchase, hold, and alienate property.	Brings all land (private/public) within planning control; allows Authority to regulate, acquire, and develop land.
21	Power to Undertake Development	- Authority can formulate and implement development schemes in its area. - Schemes can involve acquisition, assembly, re-layout, or redistribution of private land for purposeful development (e.g., roads, open spaces, commercial space, public purposes). - Can also undertake development outside its area if it is for the benefit of residents.	Allows Authority to actively develop and re-plan land, including private property, for orderly urban development.
21(3)	Development Schemes	- Authority can formulate schemes that include: - Acquisition of land by purchase, lease, or otherwise. - Layout or re-layout of vacant or built-up land. - Assembling and redistribution of	Facilitates comprehensive planning, including acquisition and redistribution of private land for public and commercial purposes.

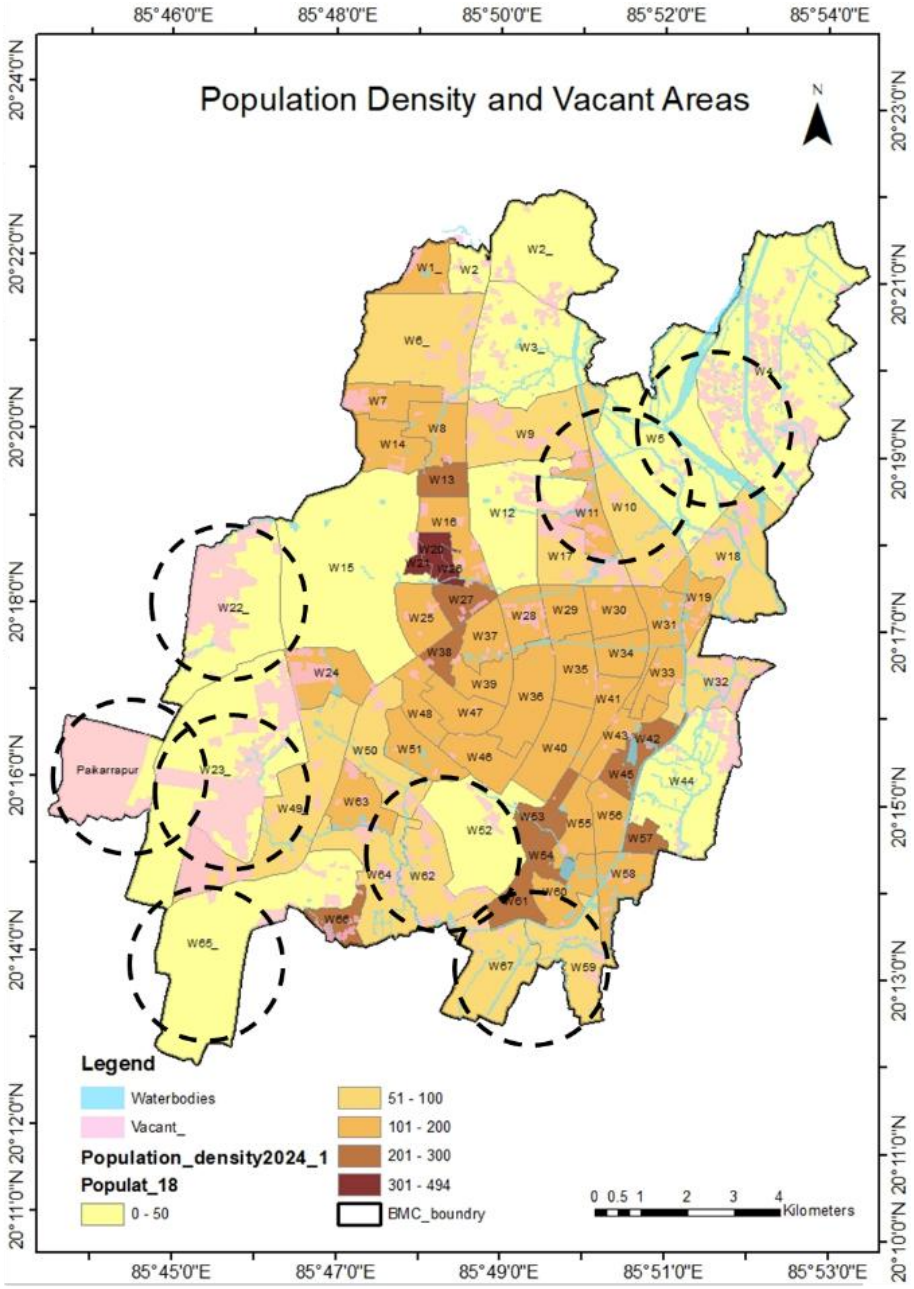
		property. - Reservation of land for open spaces, roads, schools, markets, green-belts, transport, and public purposes. - Development of housing, commercial, and industrial schemes. - Sale, leasing, or auction of scheme property.	
70	Vesting of Land in Authority	- Land purchased or transferred for development vests in the Authority. - Land held/managed by Authority for city planning purposes, including commercial development, P-SP, and green/open areas.	Secures land for public purposes under legal control and management by the Authority.
71	Power to Acquire Land	- Authority may purchase land under the Land Acquisition Act for development schemes. - Covers private land for roads, open spaces, public amenities, and commercial areas as indicated under the plan.	Legal authority for acquiring private land for planned public or commercial development.
72	Disposal of Land by Authority	- Land may be allotted, leased, or transferred for public, semi-public, and commercial uses as outlined in the prescribed procedures.	Permits Authority to assign land for public amenities, commercial, and institutional growth.
73	Management of Land	- All vested land is controlled by Authority, which ensures use is consistent with the development plan (e.g., parks, public facilities, commercial complexes).	Guarantees land usage as per the city's master plan and public interest.
74	Power to Transfer Land	- Authority can transfer land to local authorities, government departments, or agencies for public	Makes it easy for provision of land for public

		purposes (e.g., green/open spaces, P-SP uses).	infrastructure and amenities.
75	Power to Require Surrender of Land	- While sanctioning a layout or scheme, Authority may insist on private applicants surrendering some land (for roads, open spaces, public amenities) free of cost. - Surrendered land is utilized for public infrastructure, green spaces, or community facilities.	Guarantees new developments provide land for public use and infrastructure.
86	Assessment of Development Charges	- The Authority may charge and recover development fees from developers/landowners for providing infrastructure (public utilities, parks, roads, etc.). - Fees contribute to the creation and upkeep of green/open spaces, P-SP, and commercial infrastructure.	Provides financing for public infrastructure and amenities needed by new development.

Section	**Key Provisions & Powers**
The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	
The primary legal framework in India governing the acquisition of private land by the government for public purposes, including city development.	"Public purpose" includes urbanization and infrastructure projects, ensuring land acquisition serves the community's needs.
Land pooling	
A voluntary and collaborative land management technique.	Landowners can consolidate parcels for development by a government agency, as seen in the DDA Land Pooling Policy and Amaravati Land Pooling Scheme.
Transferable Development Rights (TDR)	
Allows landowners to transfer development potential to other locations, receiving compensation via development rights certificates instead of cash.	
Town Planning (TP) Scheme	

A highly effective land management tool used by government authorities in India, to facilitate the acquisition and development of private land for city development. (like in Gujarat and Maharashtra).	The Town Planning (TP) Scheme ensures organized urban growth with adequate infrastructure and public spaces.

4.6.6 LSA and Population Density



Map 37 LSA and Population Density

Vacant land has been superimposed onto the Population Density map (Map 37), giving an indication of whether vacant lands are linked with low or high population densities. The analysis identifies that a majority of vacant land is found where very low population density prevails. This is an insightful information for future urban expansion, as wards with available land and sparse population can be prioritized for development, enabling the city to address its needs of the future without putting too much pressure on existing resources.

4.7 Potentials and Issues

Based on the analysis, the potentials and issues of the city have been identified. Accordingly, further proposals, recommendations, and strategies will be developed to optimize land utilization and promote the sustainable development of the city (table 26).

Table 26 Potentials and Issues

Potentials	**Issues**
Urban Growth: • Increase of Population in wards which lies on the outer parts. • Low density development in wards with vacant areas and less population density.	**Urbanisation:** • Rapid population growth; • Urban Sprawl; • Environmental Degradation;
Economic Development: • Development of Incubation centres to increase job opportunities for people within city limits. • Development of Sub- Central Business District to enhance economic development of city.	**Inequitable Access to Services:** • Lack in infrastructure: Water network, sewerage network; Lack of recreational spaces; • Uneven distribution of Green/open spaces within city.
Infrastructure Development: • Providing water network and sewerage network, all over the city, as many wards, except from the core city areas are lacking. • Increase of Open/Green areas in across city.	**Land Use Challenges:** • High land prices in fringe areas and uneven FAR (Floor Area Ratio) regulations hinder equitable development opportunities.

Connectivity: To provide road infrastructure in outer wards where connectivity is lacking, and to increase ROW where necessary. Better connectivity can increase opportunities for development of areas.	**Connectivity:** Road connectivity in the outskirts.
	Social Inequality: Disparities in access to healthcare, education, and employment opportunities threaten inclusive development without redistributive policies.

4.8 Summary

The chapter offers a detailed evaluation of the city, beginning with the careful selection of indicators and analytical techniques. It thoroughly explores the selected themes and indicators, leading to the creation of various indicator maps. These maps are then combined to generate a land suitability map, which is analysed under three different development scenarios. The weighting of indicators for the suitability map is determined through expert surveys and the Analytic Hierarchy Process (AHP). Analysis of carrying capacity at the city and zone levels reveals that Zones 1 and 3 can only uphold current conditions through 2031, but Zone 2 is capable of sustaining them until 2041. The spatial relationship between amenities, population density, infrastructure, and land prices is explored to identify areas best suited for future development. The chapter also investigates land use and land cover changes, as well as the ownership of vacant land, focusing on the potential for development, as some of the vacant land is privately owned, so for using those land parcels, few acts have been analysed. Further, future urban growth is predicted using spatial analysis. By overlaying vacant land data with the suitability map, the analysis identifies optimal locations for development. Ultimately, the chapter highlights the city's main strengths and challenges.

CHAPTER-5 PROPOSALS AND RECOMMENDATIONS

This chapter outlines the proposals, recommendations, and strategies developed based on the analysis presented in the previous chapters. These measures are intended to help the city optimize land utilization and advance toward sustainable urban development.

5.1 Recommendations

In the previous chapter, the potentials and issues of the city were identified through analysis. Based on these findings, recommendations have been provided to address the causes of these issues and mitigate their effects.

For improved urban development, the proposals and suggestions have been grouped under three broad themes: Urban Growth and Development, Land Management, and Public Participation. These themes have been further subdivided into three implementation phases-short term (1–5 years), medium term (5–10 years), and long term (10–20 years), to facilitate proper phased and systematic approach development.

This framework seeks to optimize land use and direct the city towards sustainable development, along with encouraging better employment opportunities and lifestyles for city people.

5.1.1 Urban Growth and Development- Land Use Planning

Promoting city development through suitability analysis is an effective way to reduce urban vulnerabilities and enhance self-sufficiency. By evaluating environmental risks, infrastructure availability, and socio-economic needs, this analysis identifies optimal locations for growth and redevelopment.

This strategy reduces exposure to flood and landslide risk, promotes resource-efficient use, and supports resilient infrastructure. It also redevelops brownfields, promotes local economic development, and supports inclusive communities. It supports sustainable urban growth that balances development with efficient use of land and resources.

Inferences:

- **Strategic redevelopment of Underutilized Spaces:** Transform vacant and abandoned urban parcels into productive building sites according to suitability

analysis, safeguarding critical ecological and agricultural lands while increasing urban density and functionality.

- **Data-Driven Land Use Planning:** Institute land allocation decisions that are informed by thorough suitability analysis so that areas are properly designated for agriculture, recreation, public places, and development based on their intrinsic capabilities and limitations.
- **Preservation of Agricultural Resources:** Protect valuable agricultural lands through suitability mapping, strengthening urban self-sufficiency and food security while guiding development towards more suitable areas.

A. Comparison and suggestions

This theme deals mainly with the proposals developed for the city and further describes how these projects need to be executed in various phases. The suggestions are derived from a comparative study of the Master Plan 2030 (proposed), the Land-Use Plan 2025, and the Land Suitability Analysis (LSA) map with empty spaces (Scenario 1 LSA, as expert surveys reveal the first three themes' indicators are most prominent). Vacant land is given prime importance here for proposals.

1) The proposed Master Plan 2030, Land-Use Plan 2025, and the Land Suitability Analysis (LSA) map with vacant areas (using Scenario 1, as expert surveys indicate the first three themes are most important) have been compared, with a primary focus on vacant land for new proposals. Comparative analysis (Fig. 18) shows that, in the North-East side of the city, the proposed Land-Use Plan 2030 designates the area for Residential, Public Semi-Public (P SP), and Commercial uses. However, according to the LSA, this area is less suitable for development. In the Existing Land-Use Plan 2025, the area is identified as agricultural and vacant land.

   Suggestion: Based on this analysis, it is recommended to retain this area as agricultural land, as it is more suitable for agriculture. Preserving this land for agricultural use can help support local food security and sustainable land management.

2) In the Northern area, most of the land is designated as residential, with some portions classified as PSP (Public/Semi-Public) and industrial according to the

proposed Master Plan 2030. As per the Land Use Plan 2025, the area is marked for residential and agricultural use.

Suggestion: It is therefore suggested that PSP facilities be relocated to vacant land within the city and that residential land use also be shifted to another suitable area, as the current land is considered less suitable for development (see Fig. 18).

3) The vacant land on the West side of the city falls under moderately suitable and suitable categories for development (Fig. 18).

   Suggestion: Therefore, this vacant land can be utilized in alignment with the proposed Land Use Map of 2030.

4) The South-Western area includes land classified as less suitable, moderately suitable, and suitable for development (Fig. 18). According to the suitability analysis, land use should be assigned accordingly. Notably, in the proposed 2030 land use plan, the central part of this area is designated as residential, even though it is less suitable for such development.

   Suggestion: It is recommended that open spaces be proposed here instead of residential land use.

5) The land at the extreme Southern ends of the city falls under less suitable, moderately suitable, and suitable categories.

   Suggestion: The less suitable areas should be retained as agricultural or vegetation land use, as indicated in the existing 2025 land use plan, rather than being developed according to the proposed 2030 plan (fig. 18).

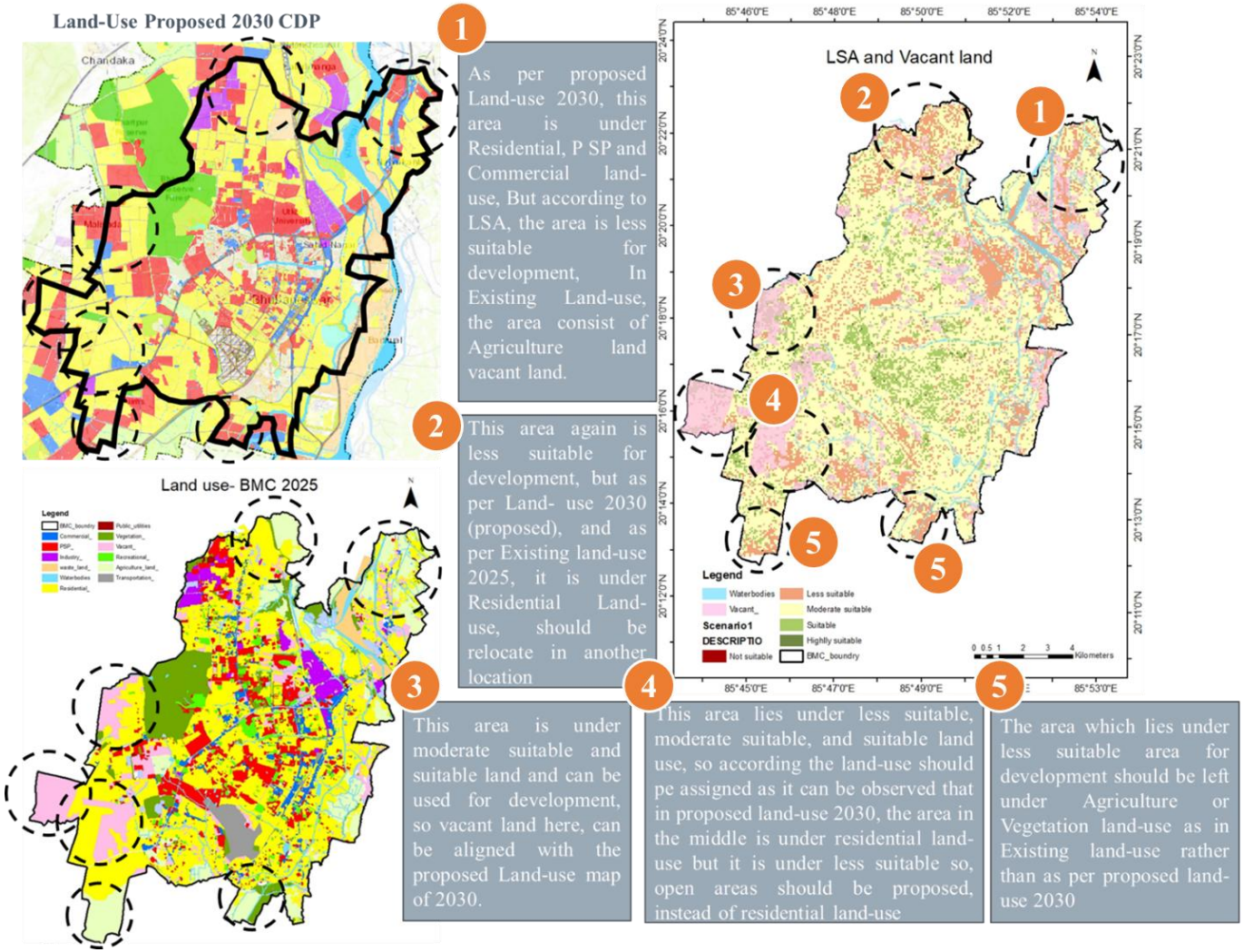
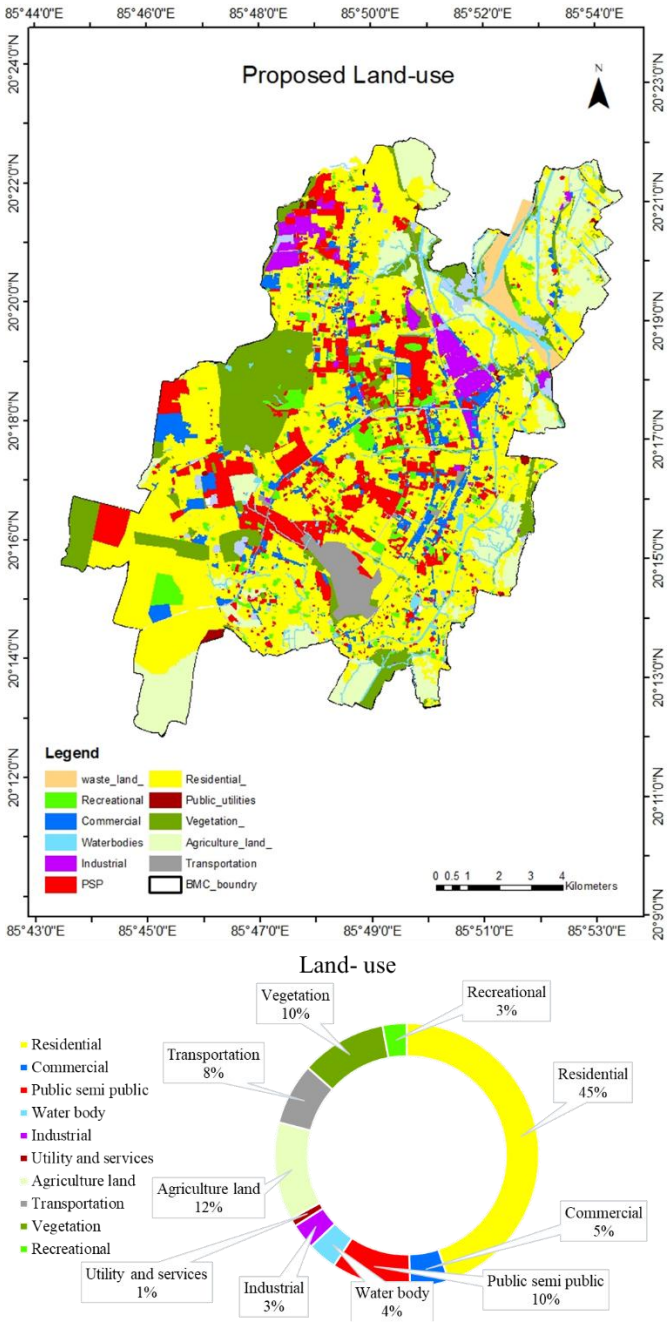

Land-Use Proposed 2030 CDP
Land use- BMC 2025
LSA and Vacant land
Legend
Waterbodies
Vacant_
Scenario1
DESCRIPTIO
Not suitable
Less suitable
Moderate suitable
Suitable
Highly suitable
BMC_boundry
1
As per proposed Land-use 2030, this area is under Residential, P SP and Commercial land-use, But according to LSA, the area is less suitable for development, In Existing Land-use, the area consist of Agriculture land vacant land.
2
This area again is less suitable for development, but as per Land- use 2030 (proposed), and as per Existing land-use 2025, it is under Residential Land-use, should be relocate in another location
3
This area is under moderate suitable and suitable land and can be used for development, so vacant land here, can be aligned with the proposed Land-use map of 2030.
4
This area lies under less suitable, moderate suitable, and suitable land use, so according the land-use should pe assigned as it can be observed that in proposed land-use 2030, the area in the middle is under residential land-use but it is under less suitable so, open areas should be proposed, instead of residential land-use
5
The area which lies under less suitable area for development should be left under Agriculture or Vegetation land-use as in Existing land-use rather than as per proposed land-use 2030

Figure 18 Comparative analysis of Masterplan 2030- proposed, Land-use plan 2025, and LSA map with vacant areas

B. Proposals

Proposal: 1 Proposed Land-use

A land-use plan has been proposed that aligns with the land suitability assessment. In this plan, vacant areas within the city have been utilized, considering that 12% of the city's land is currently vacant. Since land is a valuable natural resource that must be used efficiently, it is preferable to optimize the use of existing land within the municipal boundaries rather than expanding those boundaries prior to necessity.



Map 38 Proposed Land-use

Table 27 Proposed Land-use

Land use						
Description	**Existing-Area in sq.km.**	**Proposed-Area in sq.km.**	**Acres**	**Percentage**	**URDPFI 2014**	**Remark**
Residential	75.44	83.44	20618.47	45	36-38	Sufficient (increased by 4%)
Commercial	3.57	8.82	2179.47	5	5-6	Sufficient (increased by 3%)
Public semi public	14.29	18.05	4460.25	10	10-12	Sufficient (increased by 2%)
Water body	6.69	6.69	1653.14	4		
Industrial	5.65	5.79	1430.74	3	7-8	Shortage (increased by 1%)
Utility and services	1.76	1.87	462.09	1		
Agriculture land	20.65	22.32	5515.39	12		Increased by 1%
Transportation	13.99	13.99	3457.00	8	12-14	Shortage
Vegetation	17.56	19.54	4828.44	11		
Recreational	4.24	5.49	1356.61	3	14-16	Shortage (increased by 1%)
		186.00	45961.6	100		

The earlier analysis of the existing Land Use Plan 2025 indicates that the city is only sufficient in residential land use, while it falls short in other categories. Following the land suitability assessment and additional analyses, a proposed Land Use Plan has been developed (map 38). This new plan is now able to meet the recommended percentage requirements for several other land uses, as suggested by the URDPFI guidelines (see Table 27).

Proposal: 1.1 Proposal for Open/Green areas

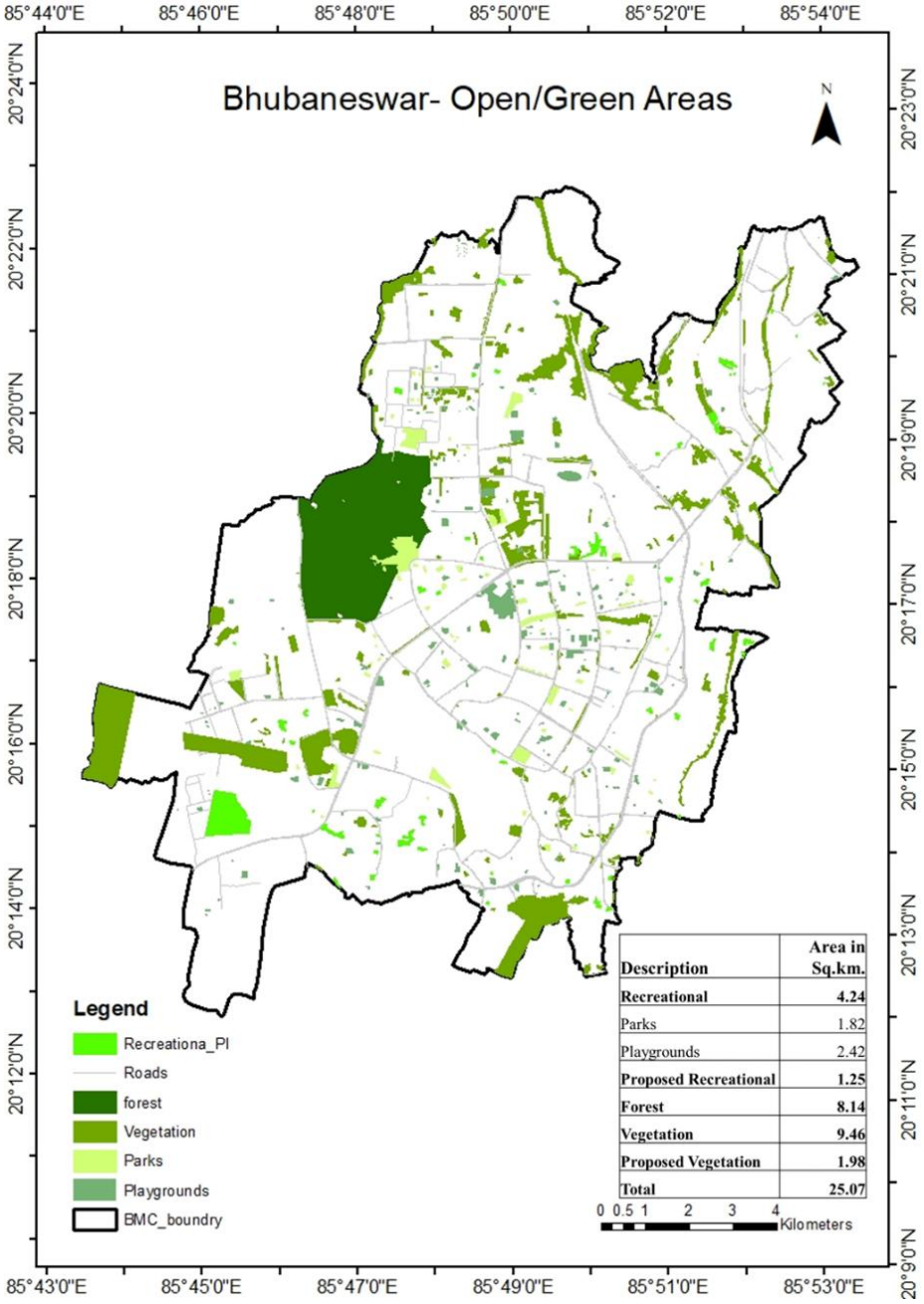
One of the identified issues is the insufficient and uneven distribution of green and recreational areas in the city. To address this, the proposed plan includes new recreational spaces as well as additional green (vegetation) areas (map 39).

Table 28 Green/Open area requirement as per URDPFI guidelines

YEAR	Population	URDPFI	Area required in sq.km.
2011	8,40,834	Minimum of 10 to 12 square meters of open space per	10.09
2021	12,87,597		15.45
2031	19,71,740		23.66
2041	30,19,391		36.23

2051	46,23,693	person in urban areas	55.48

According to URDPFI guidelines, it is recommended that urban areas provide a minimum of 10 to 12 square meters of open space per person. Based on this standard, the required open space has been calculated (see Table 28). The analysis shows that with a total of 25.07 sq. km. of open/green areas, the city can now sustain its population until 2031-a significant improvement from the previous provision of 21.84 sq. km., which was insufficient for sustainability until 2031.



Map 39 Proposed Open/Green areas

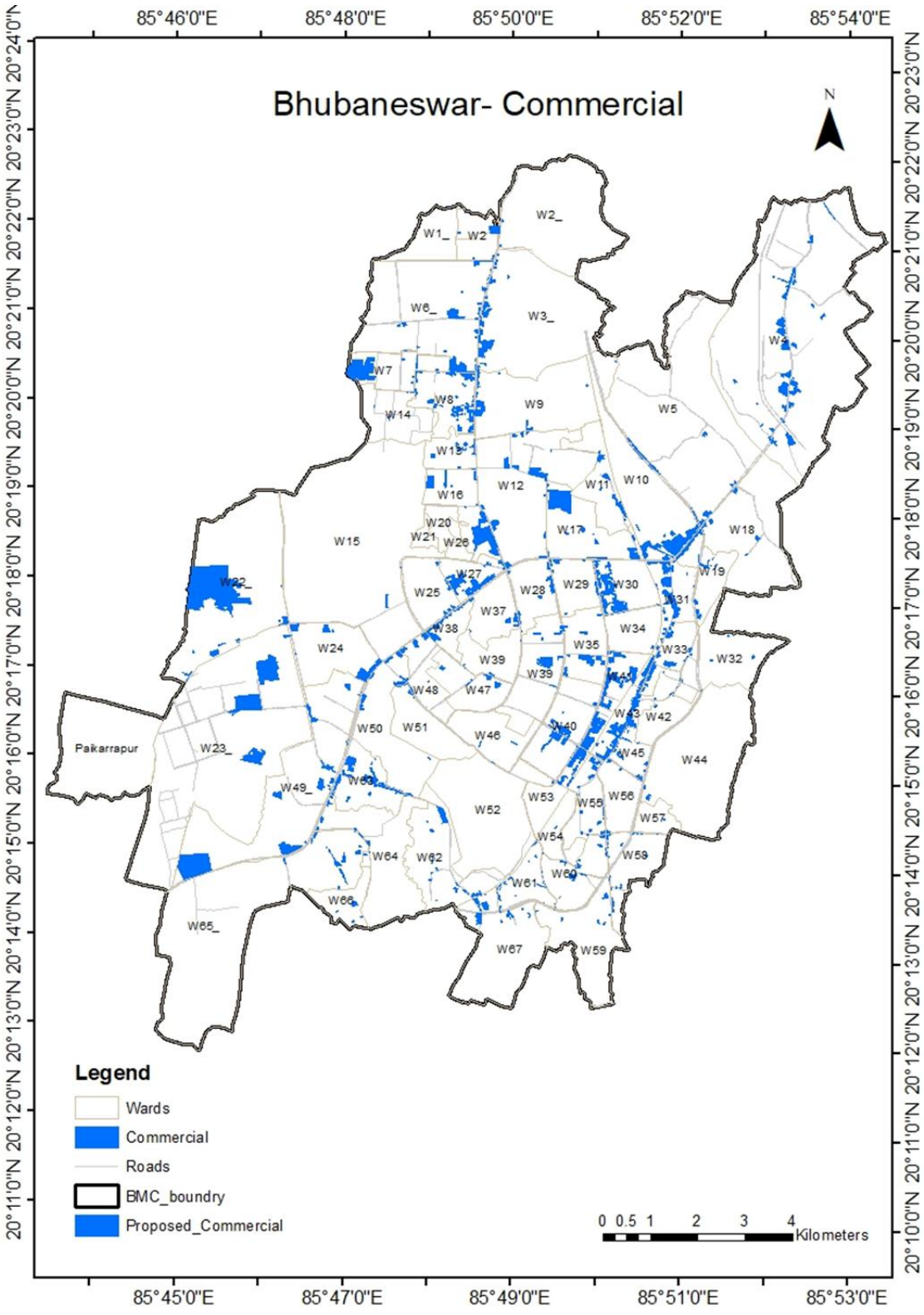
Table 29 Standards for open/green area requirement

Standard/Organization	Green Space Norms	Per Capita Equivalent	Notes	Area required in sq.km. (Considering Population 2031: 19,71,740)	Area required in sq.km. (Considering Population 2041: 30,19,391)	Remark
NRPA (National Recreation and Park Association)(USA)	40 sqm per person	4 hectares per 1000 population	Widely cited international benchmark	78.86	120.77	• After increasing the green areas from 21.84 sq.km. to 25.07 sq.km. • Now, it is catering the need of open space till 2031 as per norms or standards: URDPFI, and WHO. • As per Indian standards and NRPA norms the city lacks in green areas.
URDPFI (India)	10–12 sqm per person;	1.0–1.2 hectares per 1000 population	Indian urban planning guideline	23.66	36.23	
WHO (Global)	~9 sqm per person	0.9 hectares per 1000 population	Health-based global recommendation	17.74	27.17	
Odisha (ODA Planning & Building Standards, 2020)	Mandatory 10% open/green area reservation for projects >10,000 sqm	-	Landscape plans mandatory; green space integration	-	-	
Bhubaneswar Development Authority (BDA)	500 sqm; Plot size for landscaped open areas.	-	Planning and building regulation requirements	-	-	

In addition to comparing the green and open spaces with the URDPFI guidelines, the evaluation also looked at other applicable standards to present a holistic view of compliance. The findings suggest that besides satisfying the URDPFI requirements, the green and open spaces also comply with the WHO and Odisha Planning standards guidelines (table 29). This indicates that, based on these standards, green space provision is largely satisfactory. When compared with the National Recreation and Park Association (NRPA) USA standards, however, the city is below the stipulated levels. This comparison draws attention to the fact that though local and international standards like the WHO and Odisha are being addressed, the gap lies in meeting the more stringent NRPA standards, which tend to highlight not just the amount, but also the equitable distribution and accessibility of green spaces.

Proposal: 1.2 Proposal for Commercial areas

Analysis revealed that only 2% of the city's land is designated for commercial use, whereas URDPFI guidelines recommend 5–6%. This indicates a shortfall in commercial development, particularly in the South-West, as identified in the amenities analysis. To address this gap, and based on land suitability results, additional commercial areas have been allocated on various vacant lands across the city.



Map 40 Proposed commercial

To meet the city's requirements for commercial development and comply with URDPFI guidelines, commercial areas have been allocated in the South-West, South-East, North-

East, and North-West zones (see Map 40). This strategic distribution supports balanced urban growth and improved accessibility across the city.

Table 30 Proposed commercial areas

Land use- Proposed					
Description	**Area in sq.km.**	**Acres**	**Percentage**	**URDPFI 2014**	**Remark**
Commercial	8.82	2179.47	5	5-6	Sufficient (increased by 3%)

The initial commercial land-use provision proved to be insufficient. In accordance with the outcome of the Land Suitability Analysis (LSA), more commercial land has now been designated, increasing the total to 5% from the previous 2% (see Table 30), according to URDPFI standards. This additional provision is anticipated to further enhance the economic growth and development of the city.

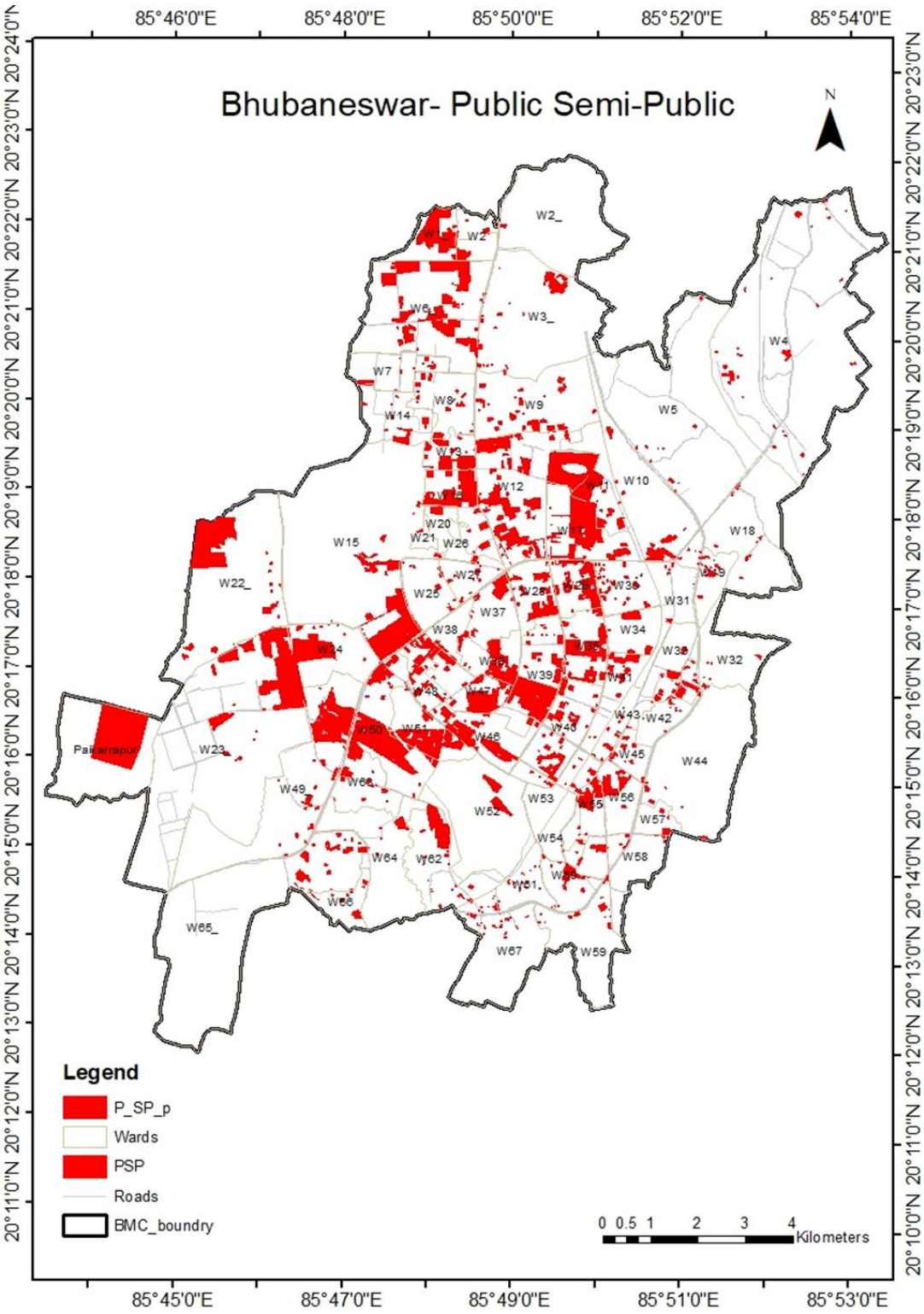
Public Semi-Public (P SP)- Proposal

The study found that the city presently has 8% of its total area as PSP land-use, which is less than the suggested 10–12% according to the URDPFI guidelines. So, there needs to be an increase in the use of PSP land to achieve these standards.

PSP land-use has been proposed in the North-East, North-West, South-West, and South regions (see Map 41). The allocation utilizes vacant areas and aligns with the results of the land suitability analysis, supporting sustainable urban development.

Table 31 Proposed Public Semi-Public areas

Land use- Proposed					
Description	**Area in sq.km.**	**Acres**	**Percentage**	**URDPFI 2014**	**Remark**
Public semi public	18.05	4460.25	10	10-12	Sufficient (increased by 2%)



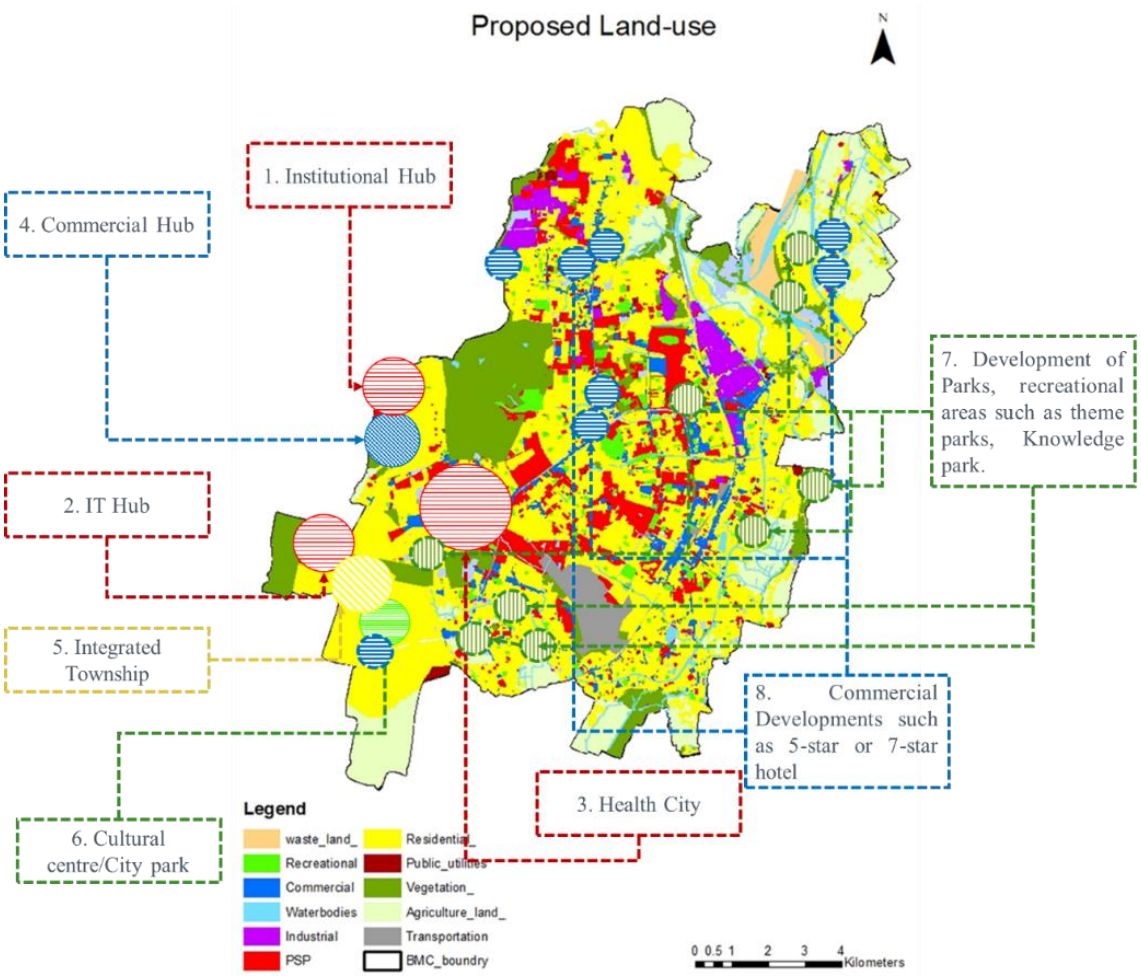
Map 41 Proposed Public Semi-Public areas

Following the allocation of the Public and Semi-Public (PSP) land, the city is now at compliance with the URDPFI guideline requirement, with PSP land rising from 8% to 10% (see Table 31). This revision results in the PSP land allocation now varying slightly from

that in the Land-use 2030 plan proposal. Interestingly, agricultural areas specified under the Land-use 2025 plan have remained constant, with agricultural areas remaining protected while fulfilling urban infrastructure requirements

C. Overall Proposals

Once the proposed land-use is developed. Projects within the city have been identified which can help in enhancing the city's quality of life, it will help in increasing job opportunities, as well as it can help in increasing the city's economy (map 42).



Map 42 Proposed projects

Under the PSP (Public and Semi-Public) land-use category, key projects such as an Institutional Hub, IT Hub, and Health City have been strategically identified.

The Institutional Hub is proposed in an area currently lacking adequate institutional facilities; its selection is further supported by the presence of minor roads that can be upgraded to improve connectivity. Locating the Institutional Hub adjacent to a commercial

area is intended to foster mutual growth and synergy, while the land itself is deemed suitable for development (table 32, map 42).

The Health City is proposed in a part of the city currently underserved by healthcare infrastructure, with the goal of providing advanced medical facilities to residents and enhancing the area's overall service profile (table 32, map 42).

The IT Hub is planned for a zone with limited existing PSP land use, aiming to direct urban growth towards less developed peripheral wards where population density is lower. This not only prevents further congestion in the city core but also situates the IT Hub near the Institutional Hub, creating opportunities for student internships and industry-academia collaboration (table 32, map 42).

For commercial use of land, emphasis is placed on tourism infrastructure development, such as the establishment of 5-star and 7-star hotels, to promote lengthier stays by tourists and boost the local economy. Since Bhubaneswar is the major airport hub of the area, it is presumed that the development will not only benefit the city but also the visitors to nearby places. Furthermore, there is a new Commercial Hub planned in a less populated region to redistribute city pressure and facilitate future growth (table 32, map 42).

Establishing incubation centres and employment-generating facilities effectively fosters local economic growth. Their integration with IT or commercial hubs ensures maximum benefit. IT hub-based centres deliver a stimulating atmosphere for technology startups, offering mentorship and investment access, whereas commercial hub centres assist small and non-tech businesses in reaching broader markets and customers. Government-supported schemes can enhance these centres by delivering funding, mentoring, infrastructure, and networking, thus resulting in a resilient entrepreneurial ecosystem. India's Atal Incubation Centres (AICs highlight the effectiveness of collaborative approaches in driving both innovation and sustainable economic advancement.

An integrated township is planned for the city's outskirts, where low population density allows for mixed-use development, thereby alleviating pressure on the urban core and promoting balanced growth (table 32, map 42).

Finally, the plan includes new and enhanced recreational and green/open spaces. Recreational areas are primarily proposed in the South-West, addressing existing infrastructure gaps, while vacant land in the city core is also allocated for such uses. These interventions aim to improve the quality of life for residents, with some existing green and recreational areas earmarked for small-scale development projects to ensure ongoing maintenance and economic vitality (table 32, map 42).

Table 32 Phase-wise development of projects

S. No.	Project	Phase	Duration	Remark
1	Institutional Hub	Medium term	5-10 years	Provide international-standard educational infrastructure and learning resources to residents of Bhubaneswar and city dwellers in the vicinity and facilitate academic success and local development.
2	IT Hub	Long term	10-20 years	Provide diversified employment opportunities and bolster the city's economic position through careful investment in sector-focused areas such as IT, research, and industry.
3	Health city	Medium term	5-10 years	Establish first-class healthcare facilities to improve public health results and facilitate the city's economic development by attracting medical tourism and ancillary support services.
4	Commercial Hub	Long term	10-20 years	Establish a second Central Business District (CBD) to facilitate balanced urbanization and stimulate growth in expanding sections of the city.
5	Integrated Township	Medium term	5-10 years	Enhance the overall standard of living through the development and improvement of urban amenities, with modern and easily accessible facilities for all citizens.
6	Cultural centre/ City Park	Medium term	5-10 years	Enhance environmental sustainability and ecological balance along with improving living conditions concurrently through green infrastructure and conservation.
7	Proposed Parks within city	Small term	1-5 years	Offer better availability and fair distribution of open and green spaces across different localities, allowing recreation and well-being for communities.

8	Commercial Development- such as 5-star/ 7-star hotels	Small/medium term	1-5 years; and 5-10 years.	Make it possible for the development of luxury accommodations, such as 5-star and 7-star hotels, to project and attract high-spending tourists and business travellers. Enhance tourism potential by filling existing infrastructure gaps, encouraging longer durations of stay, and making Bhubaneswar a leading destination.
9	Public Semi-Public areas- Development of incubation centres	Small term	1-5 years	Create long-term employment opportunities and continue to enhance the economic profile of the city through holistic urbanization and sector diversification

Projects such as IT parks, integrated townships, cultural centres, park renovations, institutional centres, and healthcare centres utilize a combination of financial models to ensure viability. Integrated townships and IT parks tend to utilize Special Purpose Vehicles (SPVs) and Public-Private Partnerships (PPPs), utilizing private investment, government grants, and at times land pooling with equity participation, as the case of Pune's Magarpatta Township indicates. Cultural and park developments often combine government support, user fees, and innovative funding models such as crowdfunding or impact bonds In contrast, institutional and healthcare projects typically opt for PPPs and SPVs, enhanced by fiscal incentives and accelerated clearances. Case studies consistently underscore the value of diversified revenue streams, efficient cost recovery, and scenario-based financial planning to ensure both public benefit and fiscal sustainability.

5.1.2 Land Management – Allocation and Monitoring of Infrastructure

Ensuring the city’s development by optimizing land allocation, and by providing as well as upgrading infrastructure, to support sustainable growth and enhance economic vitality through effective land management and continuous infrastructure monitoring.

Inferences:

- **Upgrade Existing Urban Areas: (Management and monitoring)**
  Enhance the quality and performance of urbanized areas by improving the infrastructure and city services to support higher population and activity densities. This includes strengthening the road network and filling in infrastructure gaps in a systematic way in an effort to offer better connectivity, city resilience, and liability.

- **Policy intervention (Suggestion to increase employment and development)**
  Policy action at this level is required in order to stimulate employment generation and facilitate city expansion together with the preservation of unique city characteristics, for example, a low-rise cityscape. By implementing targeted policies to support indigenous industries and businesses, economic vitality can be enhanced and more employment opportunities generated. Policy action facilitates capacity development within the city by ensuring sustainable provision of infrastructure, resources, and services to accommodate a growing population.

A. Land management (Management and monitoring)

Strategic Land Management:

Adopt land management strategies like land pooling and acquisition to facilitate holistic city development and enhance overall quality of life.

Provision of Open/Green Spaces:

Provide wide-ranging availability of parks and green spaces throughout the city to enhance recreation, public health, and ecological equilibrium.

Equitable Access to Amenities:

Dispense public amenities across the city to ensure equal access and benefits for everyone.

Creation of Public Spaces (Management and Monitoring):

Create and sustain community assets like convention centres and cultural centres to promote social interaction and community solidarity.

Smart Densification and Optimization of Infrastructure (Management and Monitoring):

Prioritize urban regeneration and infill development within areas determined as strongly suitable, hence minimizing urban sprawl, making best use of existing infrastructure, and minimizing the city's vulnerability to hazards.

B. Policy Intervention

Low rise High- density development: (Policy)

- Policy approach that balances the advantages of increased urban density with community feel of low-rise buildings.

Policy Intervention:

- Policy interventions for low-rise high-density development target zoning reform, affordability, community participation, and green urban design to provide compact, inclusive, and resilient cities.

Promote Mixed-Use Development: (Policy)

- Favor mixed-use developments, especially in the periphery or outlying wards, to form lively, multi-functional neighbourhoods.

Policy Intervention:

- Amend land-use policies to enable and encourage mixed-use development, especially around city fringes, with residential, commercial, and recreational areas.
- Offer supporting infrastructure and public transport.
- For Example, Singapore, Barcelona.

5.1.3 Public Participation – Involvement of Public Participation in Decision Making while Land-Use Planning

Public involvement at the planning stage allows for urban growth to incorporate the needs and views of the residents, thereby promoting more efficient, equitable, and broadly accepted urban solutions. Planning with the community allows planners to know local issues, creates ownership, and results in improved decision-making and sustainable

outcomes over time.

Inferences:

Including public engagement in the planning process improves city development through ensuring that the plans align with how citizens wish their city to develop. Having residents involved enables the planners to learn about local aspirations, needs, and priorities, thus coming up with more inclusive, contextually relevant, and broad-based urban solutions. Participatory methods not only result in improved planning outcomes but also create community ownership and belonging among the residents, hence more sustainable and resilient urban development.

A. Initiatives

Public Hearings and Consultations

- Hold frequent community hall sessions, public hearings, and community workshops to hear opinions on proposed plans and policies.
- Example: Numerous Indian cities, including Pune and Bengaluru, undertake public consultations prior to completing their City Development Plans (CDPs).

Participatory Surveys and Mapping

- Use participatory GIS mapping and community surveys to allow citizens to mark issues, propose changes, and indicate significant local assets or challenges.
- **Example:** The “My City, My Idea” initiative in Delhi encouraged residents to map local problems and propose solutions.

Online Platforms and Digital Engagement

- Launch interactive websites, mobile apps, and social media campaigns to collect suggestions, conduct polls, and share planning updates with the community.
- **Example:** “Smart City” portals in cities like Surat and Bhopal allow residents to submit ideas and vote on development priorities.

Workshops and Visioning Exercises

- Hold visioning workshops in which citizens, planners, and stakeholders come together to collectively develop a common vision for the future of the city.
- **Example:** Kerala's "Participatory Planning" model engaged citizens in local development project envisioning and budgeting.

Awareness and Capacity-Building Programs

- Hold educational campaigns, exhibitions, and capacity-building workshops to educate citizens about planning procedures and equip them to contribute meaningfully.

B. Benefits

- Increases transparency and trust in planning procedures, creating a good working relationship between planners and local communities.
- Involves plans to be more inclusive and responsive to local contexts using different perspectives and addressing local concerns.
- Promotes civic participation and resident responsibility, resulting in local ownership and sustainability over time.

5.2 Summary

The chapter outlines various proposals, recommendations, and suggestions that respond to the challenges identified during the analysis. The recommendations are divided under three main categories. The first category, Urban Growth and Development – Land Use Planning, includes proposals aimed at optimizing land use allocation in accordance with land suitability analysis and URDPFI guidelines. The second, Land Management – Allocation and Monitoring of Infrastructure, provides policy and management-level suggestions to address infrastructure-related issues and better urban development. The third, Public Participation – Involvement in Decision Making, suggests ways to strengthen public awareness and participation in planning. The accompanying figures illustrate the nature and scale of these recommendations: Figure 19a shows that most projects in the first category are physical in nature, implemented at the city level, and require a high budget, with some management and policy components; Figure 19b indicates that recommendations in the second category are mainly non-structural and focus on management aspects; and Figure 19c demonstrates that suggestions in the third category are typically at the ward level, management-oriented, and involve a lower budget.

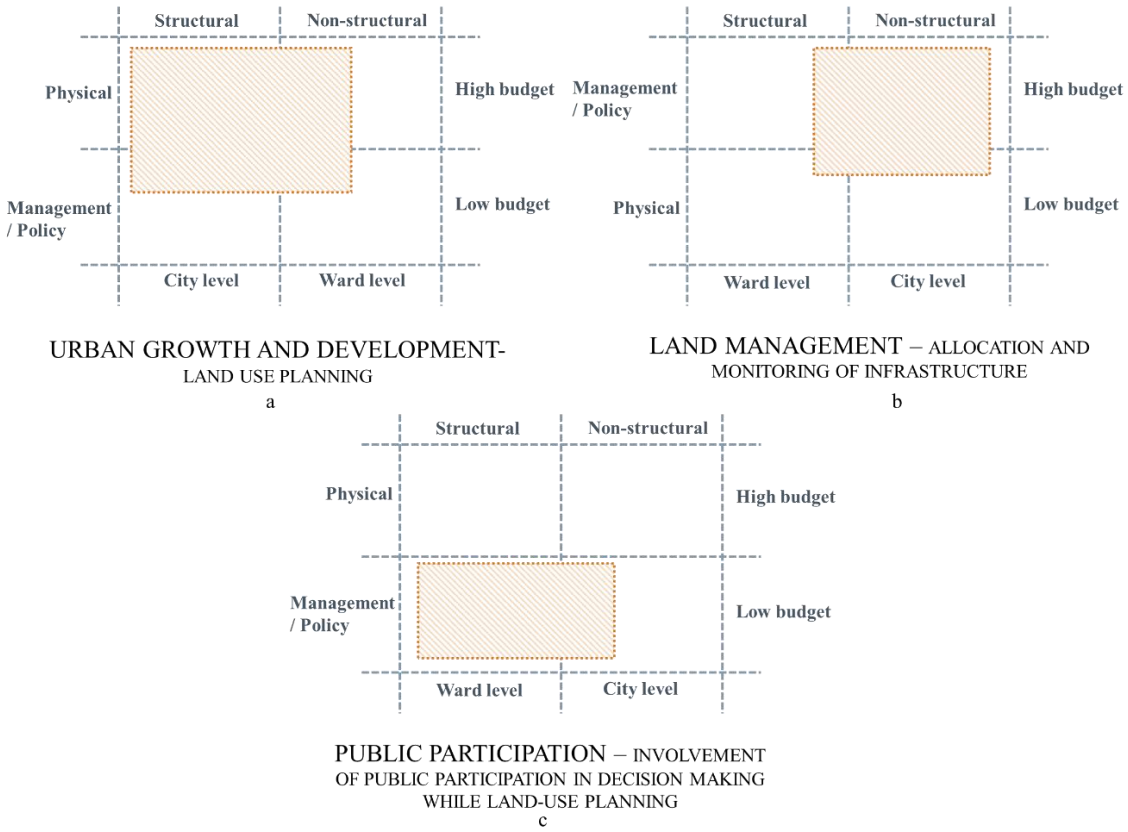


Figure 19 Recommendations: a. Urban growth and development- Land use planning, b. Land management – allocation and monitoring of infrastructure, c. Public Participation – Involvement of Public Participation in Decision Making;

CHAPTER-6 CONCLUSION

6.1 Conclusion

Urbanization poses challenges concerning land consumption and ecological balance, and thus requires sustainable urban planning measures. The integration of urban development with environmental conservation demands systematic evaluation methods. Land suitability analysis proves to be a significant technique to evaluate land parameters and development requirements for decision-making on land use. A comprehensive list of indicators and tools was obtained from previous research. A subset of indicators from this list was selected on the basis of relevance and methodological requirements for analysis. The study also explores how the weights used and the number of indicators chosen influence the final outcome, knowing that both indicator selection and weighting can have significant influence on analytical outcomes.

Bhubneshwar city was studied depending on size and population, followed by a thorough examination of its schemes, policies, and current conditions, including demographic and socio-economic features. Indicators from five themes: Natural asset, Strategic planning, Ecological and environmental factors, Prohibitive factors, and Social attributes. were selected and analysed, further maps were generated for each indicator, and three scenarios were constructed, indicator weights were determined through expert opinion and AHP analysis.

Suitability maps were generated for three scenarios (see Section 4.3 and Sub-section 4.3.2). Scenario 1 was chosen for detailed analysis. The Scenario 1 suitability map indicated that 81% of the area is developable (moderately suitable, suitable, and highly suitable classes combined), while 19% is non-developable. A comparison of the suitability map with available vacant areas (refer to Section 4.6 and Sub-section 4.6.5) showed that most available vacant land lies in areas that are suitable for development. The carrying capacity of the city was then calculated to estimate infrastructure and resource needs for sustainable development. The analysis (refer to Section 4.4, Sub-section 4.4.2) indicates that, with a Floor Area Ratio (FAR) of 2 and existing resources, the city can sustain development up to the year 2031. Additional analyses inspected the correlation among amenities, infrastructure, land values, and population (refer to Section 4.6), and land use/land cover (LULC) change assessment and prediction mapping. Vacant land was also

analysed to determine potential future development proposal opportunities (refer to Section 4.6).

Finally, the city's strengths and weaknesses were identified, and proposals, suggestions, and recommendations were made in accordance with the land suitability assessment to address these weaknesses under three themes: a. Urban growth and development- Land use planning, b. Land management – allocation and monitoring of infrastructure, c. Public Participation – Involvement of Public Participation in Decision Making. By analysing current scenarios, planners are equipped to guide future expansion in a way that prevents over-development and promotes sustainable urban growth. This approach ensures that land resources are used optimally and wisely, providing long-term benefits for the city.

So, after analysis it can be said that yes, Land Suitability Analysis (LSA) is a highly effective tool for improving land use planning and land utilization maximization. By systematic evaluation of several indicators such as road proximity, topography, soil conditions, and environmental constraints, LSA enables planners to make an informed decision about where development is most appropriately placed. By this means, less suitable areas for construction can be identified and preserved as open or green spaces. Thus, LSA not only enables the conservation of already existing green areas and agricultural land but also directs urban growth to proper locations. This approach finally achieves balance between economic growth, social needs, and environmental preservation, all of which are key to achieving sustainable urban growth.

6.1.1 Future Scope

In the future, land suitability and carrying capacity evaluations will be much more effective through the use of real-time data and enhanced community participation. This will result in more responsive and community-sensitive planning solutions. Urban development can better represent local values, enhance transparency, and bring about higher public trust and acceptability through greater public participation in the decision-making process.

These enhancements will assist planners in determining areas for sustainable development, preserving green areas, and rejuvenating underutilized sections of the city. As land is limited, maximizing its use by wise and participatory means is essential to developing cities that meet development and environmental conservation needs and ensure quality of life.

In addition, as urban analysis becomes more sophisticated with more indicators being used for a more accurate assessment, technologies such as artificial intelligence and machine learning will become crucial for enhancing the accuracy and efficiency of land suitability evaluations. This will aid in more effective and smarter urban planning decisions.

References

[1] Z. Wang, Y. Gao, X. Wang, Q. Lin, and L. Li, “A new approach to land use optimization and simulation considering urban development sustainability: A case study of Bortala, China,” *Sustain. Cities Soc.*, vol. 87, no. 35, p. 104135, 2022, doi: 10.1016/j.scs.2022.104135.

[2] A. Okacha *et al.*, “Balancing Environmental and Human Needs: Geographic Information System-Based Analytical Hierarchy Process Land Suitability Planning for Emerging Urban Areas in Bni Bouayach Amid Urban Transformation,” *Sustain.*, vol. 16, no. 15, 2024, doi: 10.3390/su16156497.

[3] S. I. Deliry and H. UyguçgİI, “GIS-Based Land Suitability Analysis for Sustainable Urban Development : A Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi GIS-Based Land Suitability Analysis for Sustainable Urban Development : A Case Study in Eskisehir , Turkey Sürdürüle,” *Afyon Kocatepe Univ. J. Sci. Eng.*, vol. 20, no. September, pp. 634–650, 2020.

[4] M. Arif, S. Sengupta, S. K. Mohinuddin, and K. Gupta, “Dynamics of land use and land cover change in peri urban area of Burdwan city, India: a remote sensing and GIS based approach,” *GeoJournal*, vol. 88, no. 4, pp. 4189–4213, 2023, doi: 10.1007/s10708-023-10860-3.

[5] M. Masoudi, M. Aboutalebi, E. Asrari, and A. Cerdà, “Land Suitability of Urban and Industrial Development Using Multi-Criteria Evaluation (MCE) and A New Model by GIS in Fasa County, Iran,” *Land*, vol. 12, no. 10, 2023, doi: 10.3390/land12101898.

[6] L. Unit, “Land Capability Assessment (LCA),” pp. 3–11.

[7] N. Delhi, “National urban housing and habitat policy,” *Indian Concr. J.*, vol. 80, no. 2, pp. 3–4, 2006.

[8] E. Gottero, F. Larcher, and C. Cassatella, “Defining and Regulating Peri-Urban Areas through a Landscape Planning Approach: The Case Study of Turin Metropolitan Area (Italy),” *Land*, vol. 12, no. 1, 2023, doi: 10.3390/land12010217.

[9] S. Angel, “Urban expansion: theory, evidence and practice,” *Build. Cities*, vol. 4, no. 1, pp. 124–138, 2023, doi: 10.5334/bc.348.

[10] M. Sharma, V. Kumar, and S. Kumar, "A systematic review of urban sprawl and land use/land cover change studies in India," *Sustain. Environ.*, vol. 10, no. 1, 2024, doi: 10.1080/27658511.2024.2331269.

[11] I. M. Badwi, "Integrated Multicriteria Approach for Assessing Land Suitability and Predicting Informal Growth: The Case of the Greater Cairo Region, Egypt," *J. Urban Plan. Dev.*, vol. 150, no. 2, pp. 1–17, 2024, doi: 10.1061/jupddm.upeng-4502.

[12] A. No, "The environment (protection) act, 1986," vol. 1986, no. 29, 1986.

[13] A. K. Verma, "ECOLOGICAL BALANCE : AN INDISPENSABLE NEED FOR HUMAN," vol. 21, no. 1, pp. 407–409, 2018.

[14] I. B. Lourenço, L. F. Guimarães, M. B. Alves, and M. G. Miguez, "Land as a sustainable resource in city planning: The use of open spaces and drainage systems to structure environmental and urban needs," *J. Clean. Prod.*, vol. 276, p. 123096, 2020, doi: 10.1016/j.jclepro.2020.123096.

[15] B. Shah Pooja, P. Sheladiya Kaushik, J. Patel, C. R. Patel, and R. M. Tailor, "Assessing Land Suitability for Managing Urban Growth: An Application of GIS and RS," *Int. Geosci. Remote Sens. Symp.*, pp. 4243–4246, 2020, doi: 10.1109/IGARSS39084.2020.9324098.

[16] A. A. azeez Hdoush, Z. Makhamreh, R. Al-Weshah, and D. Qutishat, "Land Suitability Evaluation Esing FAO Approach and Spatial Analysis for Mujib Basin – Jordan," *Jordan J. Earth Environ. Sci.*, vol. 13, no. 3, pp. 158–167, 2022.

[17] N. G. Vadivelu and S. S. Ramachandran, "Assessment of Land Suitability for Sustainable Development of Peri-Urban Areas in Coimbatore Using Gis, Ahp and Multi-Criteria Decision Making," *Environ. Eng. Manag. J.*, vol. 21, no. 6, pp. 1059–1074, 2022, doi: 10.30638/eemj.2022.095.

[18] "STRATEGIC PLANNING AS A TOOL FOR SUSTAINABLE URBAN MANAGEMENT," vol. 17, no. 2, pp. 97–109, 2015.

[19] U. Cities and L. Governments, "UCLG Policy Paper on Local Finance," *UCLG, Barcelona*, pp. 1–6, 2007, [Online]. Available: http://ns1.lux-development.lu/workshop/segou2010/docs/UCLG policy paper on local finance 2007.pdf

[20] UN-HABITAT, *Inclusive and sustainable urban planning: A Guide for Municipalities*, vol. 1. 2007.

[21] "About Smart Growth | US EPA." Accessed: Sep. 11, 2024. [Online]. Available: https://www.epa.gov/smartgrowth/about-smart-growth

[22] (University of the Sunshine Coast) WARDNER PAMELA, "Explaining Mixed-Use Developments: a Critical Realist'S Perspective Pamela," *20Th Annu. Pacific-Rim Real Estate Soc. Conf.*, pp. 19–22, 2014.

[23] MoHUA and MOHUA India, "National Transit Oriented Development (TOD) Policy," *Gov. India*, pp. 1–18, 2017, [Online]. Available: http://mohua.gov.in/upload/whatsnew/59a4070e85256Transit_Oriented_Developoment_Policy.pdf%0Ahttps://www.india.gov.in/national-transit-oriented-development-tod-policy?page=1

[24] A. Green, A. Ettya, S. McPhee, B. Ricker, and Cristina Temenos, "British Columbia in a Global Context," *Geogr. Open Textb. Collect.*, 2014, [Online]. Available: http://opentextbc.ca/geography/

[25] K. Dovey and E. Pafka, "What is walkability? The urban DMA," *Urban Stud.*, vol. 57, no. 1, pp. 93–108, 2020, doi: 10.1177/0042098018819727.

[26] R. Furlan, S. Zaina, and S. Patel, "The urban regeneration's framework for transit villages in Qatar: the case of Al Sadd in Doha," *Environ. Dev. Sustain.*, vol. 23, no. 4, pp. 5920–5936, 2021, doi: 10.1007/s10668-020-00853-4.

[27] Department of Land Resources, "National Land Utilisation Policy," no. July, pp. 9–10, 2013.

[28] MoRD, "National Land Utilisation Policy framework for land use planning & management," *Dep. L. Resour. Minist. Rural Dev.*, no. July, p. 40, 2013, [Online]. Available: https://smartnet.niua.org/sites/default/files/resources/draft_national_land_utilisation_policy_july_2013.pdf

[29] "The Constitution," *Politics*, vol. 8, no. sup1, pp. 6–8, 1974, doi: 10.1080/00323267408401376.

[30] F. Semester, “UNIT – III 73 rd and 74 th Constitutional Amenedment Acts .,” 1992.

[31] U. Heink and I. Kowarik, “What are indicators? On the definition of indicators in ecology and environmental planning,” *Ecol. Indic.*, vol. 10, no. 3, pp. 584–593, May 2010, doi: 10.1016/J.ECOLIND.2009.09.009.

[32] D. Swain, G. J. Roberts, J. Dash, K. Lekshmi, V. Vinoj, and S. Tripathy, “Impact of Rapid Urbanization on the City of Bhubaneswar, India,” *Proc. Natl. Acad. Sci. India Sect. A - Phys. Sci.*, vol. 87, no. 4, pp. 845–853, Dec. 2017, doi: 10.1007/S40010-017-0453-7.

[33] P. Paramita Jena ----------, “Urban Growth and Climate Change-A Study in the Context of Bhubaneswar City of Odisha,” *IOSR J. Humanit. Soc. Sci. (IOSR-JHSS*, vol. 23, no. 1, pp. 49–55, 2018, doi: 10.9790/0837-2304014955.

[34] T. Das, A. Jana, B. Mandal, and A. Sutradhar, *S patio-temporal pattern of land use and land cover and its effects on land surface temperature using remote sensing and GIS techniques: a case study of Bhubaneswar city, Eastern India (1991–2021)*, vol. 87, no. January. Springer Netherlands, 2022. doi: 10.1007/s10708-021-10541-z.

[35] M. Dash and M. Chakraborty, “Distribution of Green Spaces Across Socio-Economic Groups: a Study of Bhubaneswar, India,” *J. Archit. Urban.*, vol. 47, no. 1, pp. 57–67, 2023, doi: 10.3846/jau.2023.17026.

[36] Asiva Noor Rachmayani, “CDP- Bhubaneswar,” p. 6, 2015.

[37] JNNURM, “India Smart City Profile - Bhubaneswar,” pp. 1–5, 2014.

[38] O. Urban, “Odisha Housing for All Policy for Urban Areas, 2022”.

[39]: : “Bhubaneswar Municipal Corporation.” Accessed: May 25, 2025. [Online]. Available: https://www.bmc.gov.in/programs/pmay

[40] “Majhi launches ‘Bikashita Gaon, Bikashita Odisha’ scheme for rural development | Latest News India - Hindustan Times.” Accessed: May 25, 2025. [Online]. Available: https://www.hindustantimes.com/india-news/majhi-launches-bikashita-gaon-bikashita-odisha-scheme-for-rural-development-101738769922345.html

[41]: : “Bhubaneswar Municipal Corporation.” Accessed: May 25, 2025. [Online]. Available: https://www.bmc.gov.in/programs/rajiv-awas-yojana

[42]: : “Bhubaneswar Municipal Corporation.” Accessed: May 25, 2025. [Online]. Available: https://www.bmc.gov.in/programs/go-green-drive

[43] “Revolutionary Land-for-Land Policy for Displaced Farmers Announced in Odisha | Bhubaneswar News - Times of India.” Accessed: May 25, 2025. [Online]. Available: https://timesofindia.indiatimes.com/city/bhubaneswar/revolutionary-land-for-land-policy-for-displaced-farmers-announced-in-odisha/articleshow/115497336.cms

[44] “Akash Shova Building, Sachivalaya Marg Sd/-Planning Member Bhubaneswar Development Authority,” 2021.

[45] “Bhubaneswar Town Planning Gets Future Ready and 11 from Sahajpur get ROR.” Accessed: May 25, 2025. [Online]. Available: https://odisha.plus/2020/12/bhubaneswar-town-planning-gets-future-ready-and-11-from-sahajpur-get-ror/

[46] N. Kumar, “Urban Carrying Capacity Assessment for metropolitan area: Case study of Patna City, Bihar, India,” *Int. Res. J. Eng. Technol.*, vol. 4, no. 2, pp. 1561–1563, 2017, [Online]. Available: https://irjet.net/archives/V4/i2/IRJET-V4I2306.pdf